

MILITARY SPECIFICATION

CAPACITORS, FIXED, CERAMIC DIELECTRIC, (TEMPERATURE STABLE AND GENERAL PURPOSE), HIGH RELIABILITY, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for high reliability, general purpose (BX) and temperature stable (BP) ceramic dielectric fixed capacitors leaded and nonleaded for space, missile and other high reliability applications. Capacitors covered by this specification may be used in critical frequency determining applications, timing circuits, and other applications where absolute stability is required (BP) and in applications where appreciable variations in capacitance with respect to temperature, voltage, frequency and life can be tolerated (BX). Life tests in this specification are performed at 2 times rated voltage at maximum rated temperature, and an assumed acceleration factor of 8:1 is used to relate life test data obtained at 2 times rated voltage to performance at rated voltage.

1.2 Classification.

1.2.1 Military part number. Capacitors specified herein (see 3.1) shall be identified by a military part number which shall consist of the basic number of the military specification sheet followed by a series of coded characters. Each military specification sheet covers a different capacitor style. The coded number shall provide information concerning the capacitors' characteristic, working voltage, capacitance value, capacitance tolerance, and termination material. The military part number shall be in the following form as indicated:

M123	A	01	BX	B	103	K	C
1	1	1	1	1	1	1	1
Military specification number	Modification 1.2.1.1	Slash sheet number	Characteristic 1.2.1.2	Voltage 1.2.1.3	Capacitance value 1.2.1.4	Capacitance tolerance 1.2.1.5	Termination 1.2.1.6

1.2.1.1 Modification. The modification letter is used to indicate the latest characteristic of the part in the specification sheet. This letter shall be changed under direction of the preparing activity.

1.2.1.2 Characteristic. The characteristic refers to the voltage temperature limits of the capacitor. The first letter (B) identifies the rated temperature range of -55° to +125°C. The second letter indicates the voltage temperature limits as shown in table 1.

TABLE 1. Voltage-temperature limits.

Symbol	Capacitance change with reference to 25°C	
	Steps A to D incl of table XV	Steps E and G incl of table XV
P	0 ±30 ppm/°C	0 ±30 ppm/°C
X	-15, -15 percent	+15, -25 percent

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: George C. Marshall Space Flight Center, National Aeronautics and Space Administration, ATTN: EGO2, Marshall Space Flight Center, Alabama 35812 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

1.2.1.3 Voltage. The rated voltage for continuous operation at +125°C is identified by a single letter as shown in table II.

TABLE II. Rated voltage.

Symbol	Rated voltage
	<u>Volts, dc</u>
A	25
B	50
C	100
D	200
E	500

1.2.1.4 Capacitance. The nominal capacitance value, expressed in picofarads (pF) is identified by a three-digit number; the first two digits represent significant figures and the last digit specifies the number of zeros to follow. When the nominal value is less than 10 pF, the letter "R" shall be used to indicate the decimal point and the succeeding digit(s) of the group shall represent significant figure(s). For example, 1R0 indicates 1.0 pF; R75 indicates .75 pF; and 0R5 indicates 0.5 pF.

1.2.1.5 Capacitance tolerance. The capacitance tolerance is identified by a single letter in accordance with table III.

TABLE III. Capacitance tolerance.

Symbol	Capacitance tolerance
C	0.25 pF
D	0.5 pF
F	1 percent
J	5 percent
K	10 percent

1.2.1.6 Termination. The termination is identified by a single letter as shown in table IV.

TABLE IV. Termination.

Lead capacitors		Nonleaded capacitors	
Symbol	Termination type	Symbol	Termination type
C	Copper, solder coated (type C-4 or C-5 of MIL-STD-1276)	M	Palladium/silver alloy
W	Copper clad steel, solder coated (type W-4 or W-5 of MIL-STD-1276)	N	Guarded ^{1/}
		R	Palladium/silver alloy, solder coated
		S	Guarded, solder coated ^{1/}

^{1/} A guarded termination is one in which the interelectrode metallization is separated from the final finish by a barrier or guard metal; e.g., copper or nickel, etc.

2. APPLICABLE DOCUMENTS

2.1 Government specifications and standards. Unless otherwise specified, the following specifications, standards, and handbooks, of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

QQ-S-571 - Solder; Tin Alloy, Lead-Tin Alloy, and Lead Alloy.

MILITARY

MIL-C-39028 - Capacitors, Packaging of.

(See supplement 1 for list of associated specification sheets.)

STANDARDS

MILITARY

MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.

MIL-STD-790 - Reliability Assurance Program for Electronic Parts Specifications.

MIL-STD-1276 - Leads for Electronic Component Parts.

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of the specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation for bids or request for approval shall apply.

ELECTRONIC INDUSTRIES ASSOCIATION

RS-469 - Standard Test Method for Destructive Physical Analysis of High Reliability Ceramic Monolithic Capacitors.

(Application for copies should be addressed to the Electronic Industries Association (EIA), 2001 Eye Street, N.W., Washington, DC 20006.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets.

3.2 Qualification. Capacitors furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids. Distributors shall not be used (see 4.4 and 6.2).

3.3 Reliability and baseline documentation. Capacitors supplied to this specification shall conform to the requirements of MIL-STD-790 and the requirements specified herein. Prior to granting of qualification approval, a baseline document shall be prepared by the manufacturer and submitted to the qualifying activity for approval.

3.4 Design and construction. Capacitors shall be of the materials, design, construction and physical dimensions specified (see 3.1) and in accordance with baseline documentation (see 3.3).

3.4.1 Dielectric parameters. Capacitors supplied to this specification shall have a minimum dielectric thickness of 0.8 mils and a maximum dielectric constant of 2400.

3.4.2 Lead attachment (lead capacitors only) (see 3.1). Capacitors with leads shall have the leads attached to the ceramic chip body using high temperature solder with a minimum plastic point of 260°C.

3.4.3 Lead wire. Lead wire shall be in accordance with MIL-STD-1276 (see 3.1).

3.5 Nondestructive internal examination (see appendix C). Prior to termination, all capacitors delivered to this specification shall be subjected to neutron radiography, ultrasonic examination or some other method approved by the baseline (see 3.3). The method of examination shall be determined by the manufacturer. N-ray shall not be performed on characteristic BP capacitors.

3.5.1 Neutron radiography (N-ray). When capacitors are tested as specified in 4.6.1.1, there shall be no devices delivered that exhibit defects defined in appendix C.

3.5.2 Ultrasonic examination. When capacitors are tested as specified in 4.6.1.2, there shall be no devices delivered that show unacceptable responses as defined in appendix C.

3.6 Pretermination destructive physical analysis. When examined as specified in 4.6.2, parts shall meet the requirements of EIA standard RS-469.

3.7 Visual examination.

3.7.1 Pre-encapsulation visual inspection (lead capacitors only). When lead capacitors are examined as specified in 4.6.3, they shall meet the visual inspection requirements specified in appendix G.

3.7.2 Visual examination of nonlead capacitors. When examined as specified in 4.6.3, capacitors shall meet the visual requirements specified in appendix D.

3.8 Pre-encapsulation terminal strength (lead capacitors only). Capacitors shall be tested as specified in 4.6.4 and appendix E. The leads shall be pulled until rupture and the level recorded. In no case shall the termination rupture at a load less than that specified in table XIII.

3.9 Radiographic inspection (encapsulated capacitors only). When radiographed in accordance with 4.6.5, lead capacitors shall meet the following requirements (see appendix F):

- a. There shall be no evidence of improperly made connections, substandard soldering, structural weakness, or attached solder particles or slivers.
- b. The interface between each lead and capacitor element shall have solder for at least 80 percent of the interface dimension (see figure F3).
- c. The encapsulation material shall have a minimum thickness of .005 inch (dimension T, figure F3).
- d. If a lead has a portion which has been flattened to more easily accommodate the ceramic element, the formed portion of the lead must be completely inside the encapsulation material. Any unintentional nick or deformation of the leads shall not reduce the lead diameter below 90% of the minimum diameter required (see 3.1).
- e. There shall be a minimum of .005 inch between the tip of any solder spike and the edge of the case.
- f. Extraneous particles or voids in the encapsulating material shall be no greater than .005 inch in any direction.

3.10 Thermal shock and voltage conditioning. When tested as specified in 4.6.6, capacitors shall withstand the extremes of high and low temperature without visible damage and meet the following requirement with the percent defective allowed as shown in table XIV:

Dielectric withstanding voltage (at 25°C): As specified in 3.13.
 Insulation resistance (at 25°C): Shall be not less than the initial requirement.
 Insulation resistance (at elevated ambient temperature): Shall be not less than the initial requirement (see 3.14).
 Dissipation factor (at 25°C): Shall not exceed the value specified (see 3.12).
 Capacitance (at 25°C): Shall be within the tolerance specified (see 3.1).

Capacitance values no more than 5% or .5 pF, whichever is greater, for BX characteristic or 1% or .3 pF, whichever is greater, for BP characteristic beyond specified tolerance limit shall be removed from the lot but shall not be considered defective for determination of the percent defective allowed.

3.11 Capacitance (Cap). When measured as specified in 4.6.7, the capacitance shall be within the specified tolerance (see 3.1).

3.12 Dissipation factor (DF). When determined as specified in 4.6.8, the dissipation factor shall not exceed 2.5 percent for BX or 0.15 percent for SP.

3.13 Dielectric withstanding voltage (DWV). Capacitors shall withstand the direct current (dc) potential specified in 4.6.9 without damage or breakdown.

3.14 Insulation resistance (IR). When measured as specified in 4.6.10, the insulation resistance shall be not less than the value specified:

At 25°C - 100,000 megohms or 1,000 megohm-microfarads, whichever is less.
At 125°C - 10,000 megohms or 100 megohm-microfarads, whichever is less.

3.15 Destructive physical analysis. When examined as specified in 4.6.11, capacitors shall meet the requirements of EIA standard RS-469.

3.16 Terminal strength. When capacitors are tested as specified in 4.6.12, there shall be no loosening or rupturing of the terminals.

3.17 Solderability.

3.17.1 Solderability (lead capacitors). When lead capacitors are tested as specified in 4.6.13.1, the dipped surface of the leads shall be at least 90% covered with a new, smooth, solder coating. The remaining 10% may contain only small pinholes or rough spots; these shall not be concentrated in one area. Bare base metal where the solder dip failed to cover the original coating is an indication of poor solderability, and shall be cause for failure. In case of dispute, the percent of coverage with pinholes or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

3.17.2 Solderability (nonlead capacitors). Capacitors shall be tested as specified in 4.6.13.2, except Sn62, in accordance with QQ-S-571, shall be used in lieu of Sn60 and the immersed metallized surface shall be at least 85% covered with a smooth solder coating. The remaining 15% of the surface may contain small pinholes or exposed termination material; however, these shall not be concentrated in one area.

3.18 Resistance to soldering heat.

3.18.1 Resistance to soldering heat (lead capacitors). When tested as specified in 4.6.14.1, capacitors shall meet the following requirements:

Insulation resistance at 25°C: Not less than the initial 25°C requirement (see 3.14).

Capacitance change:

BX characteristic: Shall change not more than -1.0 percent to +6.0 percent from the initial measured value.

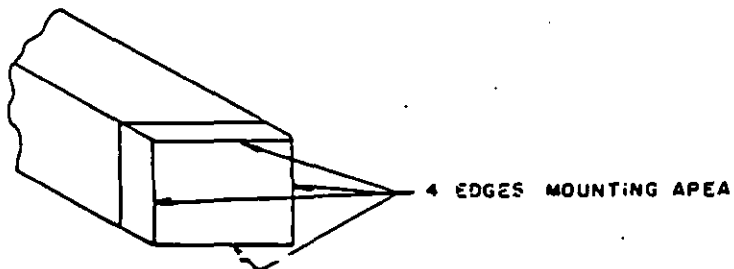
BP characteristic: Shall change not more than -1.0 percent to +2.0 percent or 0.5 pF, whichever is greater, from the initial measured value.

Dissipation factor: Shall not exceed the initial limits (see 3.12).

3.18.2 Resistance to soldering heat (nonlead capacitors). When tested as specified in 4.6.14.2, capacitors shall meet the following requirements:

Visual examination: There shall be no evidence of mechanical damage or delamination or exposed electrodes. Leaching shall be a maximum of 25 percent on each edge of mounting area (see figure 1).

Insulation resistance, capacitance change, and dissipation factor shall be measured as specified in 3.18.1.

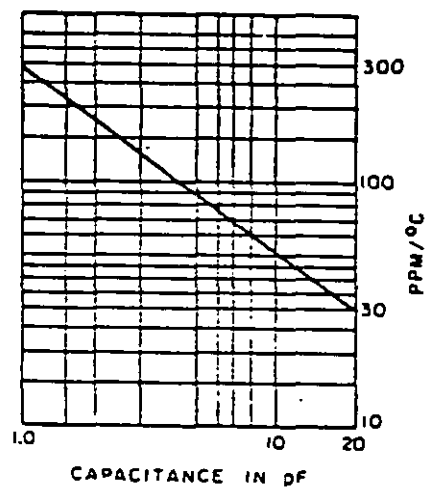
FIGURE 1. Mounting area.

3.19 Voltage-temperature limits. The capacitance change over the range of temperatures specified in 4.6.15 shall not exceed the limits specified in table V. The capacitance value obtained in step C of table IV shall be considered as the reference point. For BP values below 20 pF, see figure 2.

TABLE V. Capacitance change with reference to +25°C.

Characteristic	Steps A through D of table IV Bias = 0 volts	Steps E through G of table IV Bias = rated voltage
BX	± 15 percent	$\pm 15, -25$ percent
BP $\frac{1}{2}$	0 ± 30 ppm/°C	0 ± 30 ppm/°C

$\frac{1}{2}$ At the 25°C stability point, the capacitance measurement may be $\pm .15$ or, 0.05 pF, whichever is greater, from the 25°C reference.

FIGURE 2. Voltage-temperature limits from 1.0 to 20 pF.

3.20 Moisture resistance. When tested as specified in 4.6.16, capacitors shall meet the following requirements:

Visual examination: No mechanical damage. Marking shall remain legible.
 Dielectric withstanding voltage: As specified in 3.13.
 Insulation resistance: Not less than 50 percent of the initial 25°C requirement specified in 3.14.
 Capacitance: Change not to exceed ± 10 percent from initial measured value for BX and not more than ± 3 percent or .3 pF, whichever is greater, for BP.

3.21 Vibration, high frequency (leaded capacitors only). When capacitors are tested as specified in 4.6.17, there shall be no intermittent contacts of 0.5 millisecond (ms) or greater duration, open or short circuitry, or evidence of mechanical damage.

3.22 Resistance to solvents. When capacitors are tested as specified in 4.6.18, there shall be no evidence of mechanical damage and the marking shall remain legible.

3.23 Life (at elevated ambient temperature). When tested as specified in 4.6.19, capacitors shall meet the following requirements:

250 hour limits:

Insulation resistance (at 125°C): Shall be not less than 50% of the value specified (see 3.14).
 Visual examination: No mechanical damage. Marking shall remain legible.
 Insulation resistance (at 25°C): Shall be not less than 50% of the value specified (see 3.14).
 Capacitance: Change not to exceed ± 15 percent from the initial measured value for BX characteristic and ± 0.3 percent or 0.3 pF, whichever is greater, from the initial measured value for BP characteristic.
 Dissipation factor: Shall not exceed the value specified (see 3.12).

1,000, 2,000, and 4,000 hour limits:

Insulation resistance (at 125°C): Shall be not less 30 percent of the value specified (see 3.14).
 Visual examination: No mechanical damage. Marking shall remain legible.
 Insulation resistance (at 25°C): Shall be not less than 30 percent of the value specified (see 3.14).
 Capacitance: Change not to exceed ± 20 percent from the initial measured value for BX characteristic and ± 0.5 percent or 0.5 pF, whichever is greater, from the initial measured value for BP characteristic.
 Dissipation factor: Shall not exceed 3.0 percent for BX characteristic and 0.15 percent for BP characteristic.

3.24 Marking capacitors. Capacitors shall be marked as specified herein. Paper labels shall not be used. Other markings which in any way interfere with, obscure, or confuse those specified herein, are prohibited. Each capacitor shall be legibly marked and will withstand the environmental conditions specified herein. The marking shall be a minimum resistance of 1×10^9 ohms per square and shall remain legible after coating the parts with 1 1/2 - 3 mils of transparent conformal coating such as polyurethane, acrylic or the equivalent.

3.24.1 JAN and J marking. The United States Government has adopted, and is exercising legitimate control over, the certification marks "JAN" and "J", respectively, to indicate electrical equipment, namely, resistors, capacitors, electron tubes and the like, acquired by, or manufactured for use by, or for the Government in accordance with standard Government specifications. Accordingly, capacitors acquired to, and meeting all of the criteria specified herein and in applicable specification sheets shall bear the certification mark "JAN", except that capacitors too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be located on the first line above or below the part number. Capacitors furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein and in applicable specification sheets shall not bear "JAN" or "J". In the event a capacitor sample fails to meet the requirements of this specification and the applicable specification

sheets, the manufacturer shall remove the "JAN" or the "J" from the sample tested and also from all capacitors represented by the sample. The United States Government has obtained Certificate of Registration No. 504,860 for the certification mark "JAN". Unleaded capacitors to this specification shall not be marked with "JAN" or "J"; however, the packaging containers shall bear "JAN" or "J".

3.2.2.2 Full marking (leaded capacitors). Unless otherwise specified (see 3.1), capacitors shall be marked with the "JAN" or "J" marking, part number, date and lot code, manufacturer's five digit federal supply code (FSCM), voltage, capacitance, and capacitance tolerance. There shall be no space between the symbols which comprise the part number. The date code and lot number shall consist of the year, week, and lot code. For example: The third week of 1981 would be 8103--. Capacitors shall be marked in accordance with one of the following examples (see 3.1):

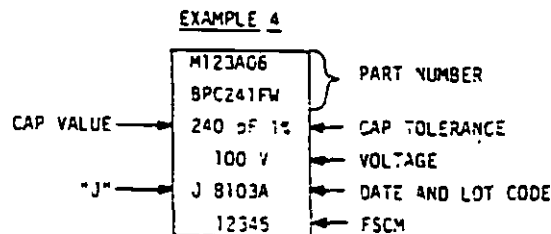
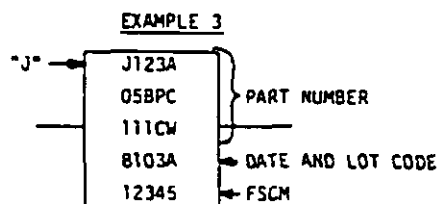
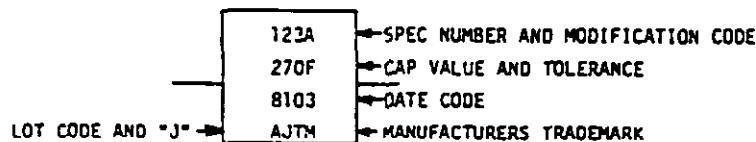
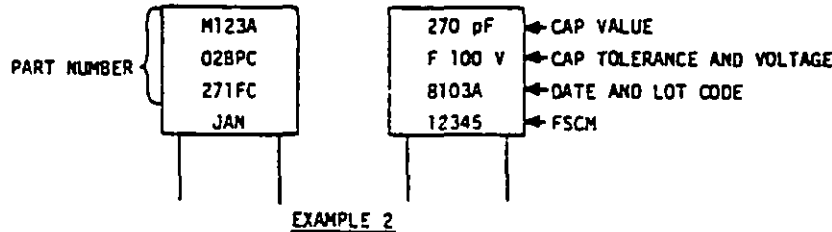
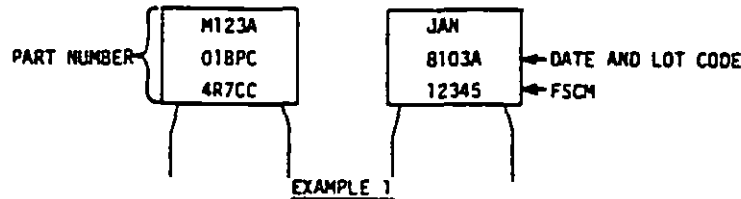


FIGURE 3. Marking examples for leaded capacitors.

3.24.3 Marking (nonleaded capacitors). Capacitors shall be legibly marked in a contrasting color, with a three digit capacitance code (see 1.2.1.5). When capacitors are too small for three digits, they shall be marked in accordance with table VI.

TABLE VI. Marking for small nonleaded capacitors.

Character	Significant units	Capacitance (pF) and multiplier					
		Orange (X 0.1)	Black (X 1.0)	Green (X 10)	Blue (X 100)	Violet (X 1000)	Red (X 10,000)
A	10	1.0	10	100	1000	10,000	100,000
B	11	1.1	11	110	1100	11,000	110,000
C	12	1.2	12	120	1200	12,000	120,000
D	13	1.3	13	130	1300	13,000	130,000
E	15	1.5	15	150	1500	15,000	150,000
H	16	1.6	16	160	1600	16,000	160,000
I	18	1.8	18	180	1800	18,000	180,000
J	20	2.0	20	200	2000	20,000	200,000
K	22	2.2	22	220	2200	22,000	220,000
L	24	2.4	24	240	2400	24,000	240,000
N	27	2.7	27	270	2700	27,000	270,000
O	30	3.0	30	300	3000	30,000	300,000
R	33	3.3	33	330	3300	33,000	330,000
S	36	3.6	36	360	3600	36,000	360,000
T	39	3.9	39	390	3900	39,000	390,000
V	43	4.3	43	430	4300	43,000	430,000
W	47	4.6	47	470	4700	47,000	470,000
X	51	5.1	51	510	5100	51,000	510,000
Y	56	5.6	56	560	5600	56,000	560,000
Z	62	6.2	62	620	6200	62,000	620,000
3	68	6.8	68	680	6800	68,000	680,000
4	75	7.5	75	750	7500	75,000	750,000
7	82	8.2	82	820	8200	82,000	820,000
9	91	9.1	91	910	9100	91,000	910,000

3.25 Workmanship. Capacitors shall be processed in such a manner as to be uniform in quality, and when visual inspection is performed under 10X, capacitors shall be free from pits, corrosion, cracks, chips and other defects that will affect life, serviceability or appearance.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Reliability assurance program. A reliability assurance program shall be established and maintained in accordance with MIL-STD-790. Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.

TABLE VII. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures <u>1/</u>
Group I				
Radiographic inspection (leaded devices only)	3.9	4.6.5	11	N/A
Thermal shock and voltage conditioning	3.10	4.6.6	174 min <u>2/</u>	see Table XIV
Dielectric withstanding voltage	3.13	4.6.9		
Insulation resistance 25°C	3.14	4.6.10		
Insulation resistance 125°C	3.14	4.6.10		
Capacitance	3.11	4.6.7		
Dissipation factor	3.12	4.6.8		
Group II				
Visual and mechanical examination; material, design, construction and workmanship	3.1, 3.4, 3.24, and 3.25	4.6.3	15	1
Destructive physical analysis	3.15	4.6.11		
Group IIIa - Leaded devices				
Terminal strength	3.16	4.6.12.1	12	1
Solderability	3.17.1	4.6.13.1		
Resistance to soldering heat	3.18.1	4.6.14.1		
Group IIIb - Nonleaded devices				
Terminal strength	3.16	4.6.12.2	12	1
Solderability	3.17.2	4.6.13.2	12	
Resistance to soldering heat	3.18.2	4.6.14.2		
Group IV <u>3/</u>				
Voltage-temperature limits	3.19	4.6.15	12	1
Moisture resistance	3.20	4.6.16.2		
Group V				
Humidity, steady state, low voltage	3.20	4.6.16.1	12	0
Vibration, high frequency (leaded capacitors only)	3.21	4.6.17	12	1
Resistance to solvents	3.22	4.6.18		
Group VI				
Life	3.23	4.6.19	123	1

1/ A sample unit having one or more defects will be charged as a single defective.

2/ Additional samples over the 174 minimum should be included, based on table XIV to allow for the percent defective allowable. Twelve additional samples will be required for nonleaded devices.

3/ Leads may be soldered to chip capacitor to facilitate the tests required in group IV.

4.2 Classification of inspections. The inspections specified herein are classified as follows:

- a. Qualification inspection (see 4.4).
- b. In-process inspection (see 4.5.1).
- c. Quality conformance inspection (4.5.2 and 4.5.3).

4.3 Inspection conditions and reference measurements.

4.3.1 Conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202 except relative humidity shall not exceed 75 percent. Accuracy of all test voltage measurements shall be within ± 2.0 percent of the specified voltage.

4.3.2 Reference measurements. When requirements are based on comparative measurements made before and after conditioning, the reference measurement shall be considered the last measurement made at $25 \pm 3^\circ\text{C}$ prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

4.3.3 Power supply. The power supply used for life testing shall have a regulation of ± 2 percent or less of the specified test voltage.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the qualifying agency (see 6.3) on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. The number of capacitors to be specified for qualification inspection shall be as specified in table VII and in appendix A of this specification. Each capacitor style shall be qualified separately.

4.4.2 Test routine. Sample units shall be subjected to the qualification inspection specified in table VII in the order shown. Sample units shall have been subjected to the in-process screening required by this specification and all sample units shall be subjected to the inspection of group I. The sample shall then be divided as specified in table VII as applicable.

4.4.3 Failures. Failures in excess of those allowed in table VII shall be cause for refusal to grant qualification approval.

4.4.4 Retention of qualification. To retain qualification for capacitors specified in this specification, the manufacturer shall forward a report at 12-month intervals to the qualifying activity. The qualifying activity shall establish the initial reporting date. The report shall include the following:

- a. A list of all device types for which the manufacturer has qualification, showing the total number of lots completing quality conformance inspection during the reporting period.
- b. Certification that the manufacturer still has the capabilities and facilities necessary to produce these items to the qualified levels.
- c. The number of lots which failed lot by lot testing or periodic testing (group B or group C).
- d. For failed lots (group B and C) the following information is required:
 - (1) Inspection lot identification code and part number(s) in the failed lot.
 - (2) The percent defective of voltage conditioning.
 - (3) The results of groups A, B, and C testing (i.e., pass or fail).
 - (4) For failed subgroups, the number and mode of all failures.
 - (5) All lots withdrawn shall be counted as failed lots in the report.
 - (6) Identification of the lots (by inspection lot identification, code part number and date of completion of group B testing).
- e. Certification for each device style which has been qualified, stating that at least two lots have been manufactured utilizing the design and construction for which qualification is valid during the 12-month reporting period.

The report shall also include certification that the design and construction of the product was verified and found to be identical to the style for which qualification approval was valid. If the summary of test results indicates nonconformance with the requirements of this specification and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list. Failure to submit the summary report within 30 days after the end of 12-month period may result in loss of qualification for products within that capacitor's group. In addition to the periodic submission of inspection data, the manufacturer shall within 30 days notify the qualifying activity at any time during the 12-month period that the inspection data indicates inability of the qualified product to meet the requirements of this specification. If during two consecutive reporting periods there has been no quality conformance inspection of product within a qualified technology, the manufacturer may, at the discretion of the qualifying activity, be required to submit a representative product(s) of that qualified technology to complete testing in accordance with the qualification requirements. In this case the product submitted must comply with the baseline for each dielectric type.

4.5 In-process inspection and quality conformance inspection.

4.5.1 In-process inspection. Each production lot of parts shall be inspected in accordance with table VIII. The use of neutron radiography or ultrasonic examination shall be as specified in baseline documentation. Other screening examinations may be applied at the option of the manufacturer, as documented and approved by the baseline (see 3.3).

4.5.1.1 Rework. Rework is not allowed on any operations including and subsequent to the formation of the slurry, except for marking and lead rework.

TABLE VIII. In-process inspection.

Inspection	Requirement paragraph	Test method paragraph	Sample size
Nondestructive internal examination	3.5	4.6.1	100%
Pre-termination destructive physical analysis	3.6	4.6.2	Table XII
Visual examination	3.7	4.6.3	100%
Pre-encapsulation terminal strength (leaded capacitors only)	3.8	4.6.4	Table XIII

4.5.2 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspection.

4.5.2.1 Inspection lot. An inspection/production lot shall be of one design as specified in the baseline documentation. As a minimum requirement, the lot shall consist of all the capacitors of a single nominal capacitance/voltage rating of one design, from the same dielectric material batch, and processed as a single lot through all manufacturing steps on the same equipment, to the same baseline/revision, and identified with the same date and lot code designation. The lot may contain all available capacitance tolerances for the nominal capacitance value (see baseline documentation for BP characteristic). In addition, the lot shall conform to the following:

- a. Raw materials such as end terminations, ceramic raw material, binders, electrode ink, shall be traceable to the same lot or batch and be from the same contractor.
- b. A lot number shall be assigned before electrode printing (inking) and be manufactured from the same slurry and cast on the same belt or comparable equipment (see 3.4).

- c. A single mix of a basic ceramic formulation fired through one kiln with one temperature profile during the process, with constant dielectric design, with, in general, no more than 20 percent variation in the number of active dielectrics being assembled in one continuous buildup. Sublots may be allowed to provide a spread in capacitance value to improve the yield. This will normally be done in the case of tight tolerances and low capacitance. In some cases, more than 20 percent variation in the number of active dielectrics may be required in these circumstances (see 3.3).
- d. End termination material shall be consistent in formulation and traceable to a single batch and shall be fired in the same kiln with no temperature adjustment during the process. All parts shall enter the kiln in one continuous operation/run for end termination firing.
- e. Lead attachment solder shall be of a uniform composition from a single supplier with a minimum melting point of 260°C.
- f. Lot identity shall be maintained from the time the lot is assembled to the time it is accepted.
- g. The lot date code (LDC) shall be added after firing and prior to end termination for leaded devices, and after end termination firing for non-leaded devices.

4.5.2.2 Group A inspection. Group A inspection shall consist of the inspection specified in table IX. Failure to meet PDA shall cause the lot to be rejected. Summary of group A data shall be forwarded to purchaser with parts.

TABLE IX. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Sample size	PDA
Subgroup 1				
Thermal shock and voltage conditioning	3.10	4.6.6.1 & 4.6.6.2	100%	See table XIV
Voltage conditioning @ 85°C	3.10	4.6.6.3	100%	XIV PDA overall req. only
Dielectric withstanding voltage (DWV)	3.13	4.6.9.1	100%	
Insulation resistance @ 25° (IR)	3.14	4.6.10	100%	
Capacitance	3.11	4.6.7		
Dissipation factor	3.12	4.6.8		
Radiographic inspection (encapsulated capacitors only)	3.9	4.6.5		
Subgroup 2				
Visual and mechanical inspection; material, physical dimensions, design, construction, marking, and workmanship	3.1, 3.4, 3.24, and 3.25	4.6.3	.65 AQL	AQL level II
Subgroup 3				
Destructive physical analysis	3.15	4.6.11	See table XII	See table XII
Subgroup 4				
Dielectric withstanding voltage (DWV) (CKS26 only)	3.13	4.6.9.2	.65 AQL	AQL level II

- 1/ For solder coated nonleaded capacitor chips, thermal shock and voltage conditioning per 4.6.6.1 and 4.6.6.2 may be performed prior to addition of final metallization; and if performed, shall not be required during group A.
- 2/ Voltage conditioning at 85°C is only required for solder coated nonleaded capacitor chips that had voltage conditioning performed prior to final metallization.
- 3/ After voltage conditioning, stabilize at 25°C for 10 hours minimum, 24 hours maximum before CAP or DF measurement.

4.5.2.3 Group B inspection. Group B inspection shall consist of the tests specified in table X and shall be performed on sample units from lots which have been subjected to and have passed Group A inspection. Copies of Group B data shall be forwarded to purchaser with parts. Parts may not be shipped until the conclusion of 1,000 hours of life test. 4,000 hour data shall be provided the qualifying activity every six months, for information only.

TABLE X. Group B inspection.

Inspection	Requirement paragraph	Test method paragraph	Sample size	Accept/reject
Subgroup 1				
Thermal shock	3.10	4.6.6.1	Table XVI	Table XVI
Life test	3.23	4.6.19	Table XVI	Table XVI
Subgroup 2				
Humidity, steady state, low voltage	3.20	4.6.16.1	12	0
Subgroup 3				
Voltage temperature-limits	same samples	4.6.15	12	1
Moisture resistance		4.6.16.2		

4.5.3 Periodic inspection. Periodic inspection shall consist of group C inspection. Except where the results of this specification show noncompliance with the applicable requirements, delivery of products which have passed group A and B inspection shall not be delayed pending the results of these periodic inspections. Group C data shall be submitted to the qualifying activity every six months.

4.5.3.1 Group C inspection. Group C inspection shall consist of the tests specified in table XI in the order shown. Samples having group C testing shall be selected from lots that have passed group A and have been submitted for group B inspection. Twelve samples shall be selected every two months. Capacitance values manufactured during the period shall be represented as far as practical in at least the approximate ratio of production.

TABLE XI. Group C inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of units to be inspected	Number of defectives permitted
Subgroup 1 - Leaded devices				
Terminal strength	3.16	4.6.12.1	12	1
Solderability	3.17.1	4.6.13.1		
Resistance to soldering heat	3.18.1	4.6.14.1		
Solvent resistance	3.22	4.6.18		
Subgroup 2 - Chip devices				
Terminal strength	3.16	4.6.12.2	12	1
Solderability	3.17.2	4.6.13.2	12	
Resistance to soldering heat	3.18.2	4.6.14.2		

4.5.3.2 Disposition of sample units. Sample units which have been subjected to group B and C inspection shall not be delivered on the contract. These samples shall be maintained by the manufacturer for a minimum of 5 years.

4.5.3.3 Noncompliance. If a sample fails to pass group C inspection, the manufacturer shall notify the qualifying activity and cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials and processes, and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the qualifying activity. Group A (and B if applicable) inspection may be reinstituted; however, final acceptance shall be withheld until the group C inspection has shown that corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

4.5.4 Inspection of packaging. The sampling and inspection of the preservation, packing and container marking shall be in accordance with the requirements of MIL-C-39028.

4.6 Methods of inspection.

4.6.1 Nondestructive internal examination (see 3.5).

4.6.1.1 Neutron radiography (see 3.5.1). Capacitors shall be subjected to neutron radiography as specified in appendix C and as defined in baseline documentation (see 3.3).

4.6.1.2 Ultrasonic examination (see 3.5.2). Capacitors shall be subjected to ultrasonic examination as specified in appendix C and as defined in baseline documentation (see 3.3).

4.6.2 Pretermination destructive physical analysis (see 3.6). Capacitors shall be examined as specified in EIA standard MS-469 and in accordance with table XII.

TABLE XII. Destructive physical analysis sample size.

Lot size	Minimum sample size	Accept	Reject
1 - 500	14	1	2
501 - 1,200	20	1	2
1,201 - 10,000	32	2	3

4.6.3 Visual examination (see 3.7). Capacitors shall be 100 percent examined under magnification as specified in the applicable appendix and shall meet the visual requirements of appendix G for leaded capacitors and appendix D for nonleaded capacitors.

4.6.4 Pre-encapsulation terminal strength (leaded capacitors only) (see 3.8). Capacitors shall be examined as specified in appendix E and in accordance with table XIII.

TABLE XIII. Pre-encapsulation terminal strength.

Lead configuration	Lead pull minimum	Sample size
Radial per lead	2.0 \pm 0.2 kg (4.4 lbs.)	10 or 25 1/
Axial per lead	2.0 \pm 0.2 kg (4.4 lbs.) all styles except CKS11 and CKS12 1.0 \pm 0.1 kg (2.2 lbs.)	10 or 25 1/

1/ whichever is greater, up to 32 pieces maximum.

4.6.5 Radiographic inspection (encapsulated capacitors only). The leaded capacitors shall be radiographed in accordance with 3.9 and appendix F. The following details shall apply:

- Number of views: (See appendix F, figure F2).
Radial lead style capacitors - one view perpendicular to the plane of the leads.
Axial lead style capacitors - two views perpendicular to the plane of the leads, with the second view made after rotation of the capacitor 90° around its own axis.
- Inspection of films: The films shall be inspected on a back-lighted illuminator using a minimum of 10X magnification.
- Defects: Capacitors containing any defects as specified in 3.9 and appendix F, figure F3 shall be rejected.
- Summary data of inspection results: A summary of the results of radiographic inspection (number of parts inspected, number accepted, number rejected) shall be included on the report of group A inspection furnished with each shipment of capacitors.
- Retention of films: Radiograph films and test reports shall be retained by the manufacturer for a minimum period of 5 years.

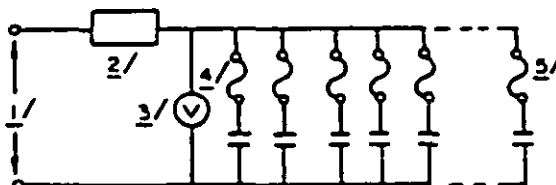
4.6.6 Thermal shock and voltage conditioning (see 3.10). Capacitors shall be subjected to the tests of 4.6.6.1 and 4.6.6.2, as applicable (see tables VII, IX, and X).

4.6.6.1 Thermal shock. Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following details shall apply:

- Test condition - A, except that in step 3, sample units shall be tested at +125°C.
- For qualification testing: 100 cycles of thermal shock.
- For group B testing: 20 cycles of thermal shock.
- For group C testing: 100 cycles of thermal shock.

4.6.6.2 Voltage conditioning (see 3.10). Voltage conditioning shall be started after completion of the thermal shock test. The voltage conditioning shall consist of applying twice the rated voltage to the units at the maximum rated temperature of 125°C for a minimum of 168 hours and a maximum of 264 hours. The voltage conditioning may be terminated at any time during 168 hours to 264 hour time interval that failures (blown fuses or less than 95% voltage) meet the requirements for the PDA during the last 50 hours listed in table XIV. Voltage shall be applied and shall reach maximum value within one second, maximum. To assure that at least 95% of the applied test voltage is maintained for the duration of the exposure period, the following circuit shall be used. After completion of the exposure period, the unit shall be allowed to stabilize at room temperature (25°C). After stabilization at room temperature, the dielectric withstanding voltage and insulation resistance shall be measured as specified in 4.6.9 and 4.6.10, respectively. After measurement of dielectric withstanding voltage and insulation resistance at 25°C, the unit shall be stabilized at maximum rated temperature and insulation resistance measured. After allowing the unit to stabilize at room temperature for 10 hours minimum, the capacitance and dissipation factor shall be measured as specified in 4.6.7 and 4.5.8, respectively. If the voltage conditioning test is performed with individual fuses in series with each part, any part tested in a position where a fuse fails shall be tested for insulation resistance and dielectric withstanding voltage. If the part meets the initial requirements for insulation resistance and dielectric withstanding voltage, the part shall be rejected but shall not count against the percent defective allowed in table XIV.

4.6.6.3 Voltage conditioning at 85°C for nonleaded solder coated chip capacitors (see 3.10). Voltage conditioning (see table IX) shall consist of applying twice the rated voltage to the units at 85°C for 48 hours. The voltage conditioning circuit and measurements of capacitance, dissipation factors, dielectric withstanding voltage and insulation resistance at 125°C shall be the same as that described in paragraph 4.6.6.2.



NOTES:

1. The power supply shall be capable of providing a minimum of twice the rated voltage of the capacitors at a fault current of 30 mA minimum.
2. The current limiting device shall be a resistor and/or a fuse. The current shall be limited to no less than 30 mA and no more than 10 A.
3. There shall be a voltage monitor that will trigger an alarm and shut off the test if the applied voltage drops by more than 5 percent.
4. Fuses shall be optional and resistors shall not be allowed. If the fuses are used, the total resistance of the fuse, connections and the connecting wires shall not exceed 50 ohms at -125°C.
5. The capacitor bank shall be no less than ten (10).

FIGURE 4. Voltage conditioning circuitry.

TABLE XIV. Voltage conditioning PDA.

Style	PDA overall	PDA last 50 hours
CKS05	3%	1 unit or 0.1%
CKS06	3%	1 unit or 0.1%
CKS07	5%	1 unit or 0.2%
CKS26	5%	1 unit or 0.2%
CKS11	3%	1 unit or 0.1%
CKS12	3%	1 unit or 0.1%
CKS14	3%	1 unit or 0.1%
CKS15	5%	1 unit or 0.2%
CKS16	5%	1 unit or 0.2%
CKS51	3%	1 unit or .1%
CKS52	3%	1 unit or .1%
CKS53	3%	1 unit or .1%
CKS54	3%	1 unit or .1%

4.6.7 Capacitance (see 3.11). Capacitors shall be tested in accordance with method 305 of MIL-STD-202. The following detail and exception shall apply:

- a. Test frequency - 1 megahertz ± 100 kHz when the nominal capacitance is 100 pF or less for BX characteristics and 1,000 pF or less for BP characteristic. 1 kHz ± 100 Hz when the nominal capacitance is greater than above.
- b. Voltage - a root-mean-square potential of 1.0 ± 0.2 volts for 1 kHz measurements and less than 1.0 volts for 1 MHz measurements.

NOTE: Following a dielectric withstanding voltage or insulation resistance test, capacitance measurement may be delayed for a period of up to 24 hours.

4.6.8 Dissipation factor (see 3.12). The dissipation factor shall be measured with a capacitance bridge or other suitable method at the frequency and voltage specified in 4.6.7. The inherent accuracy of the measurement shall be ± 2 percent of the reading plus 0.1 percent dissipation factor (absolute) unless otherwise specified. Suitable measurement techniques shall be used to minimize errors due to the connections between the measuring apparatus and the capacitor.

4.6.9 Dielectric withstanding voltage (see 3.13).

4.6.9.1 Dielectric. Capacitors shall be tested in accordance with method 301 of MIL-STD-202. The following details shall apply:

- a. Magnitude and nature of test voltage - 250 percent of the dc rated voltage.
- b. Duration of application of test voltage - 5 ± 1 seconds. The test voltage shall be raised from 0 to the specified value within 1 second, maximum.
- c. Points of application of test voltage - Between the capacitor-element terminals.
- d. Limiting value of surge current - Shall be limited between 30 and 50 milliamperes.
- e. Examination after test - Capacitors shall be examined for evidence of damage and breakdown.

4.6.9.2 Body insulation. Leaded capacitors shall be tested as specified in 4.6.9.1 with the following exception:

- a. Points of application of test voltage - Capacitors shall be wrapped with a conductive tape or foil so that the conductive tape or foil shall not be less than 0.0625 inch and not more than 0.125 inch away from the lead wires. A dc potential of 500 Vdc shall be applied between the two leads connected together and the tape or foil for a period of 5 ± 1 seconds. The test circuit shall be so arranged that the surge current does not exceed 50 mA.

4.6.10 Insulation resistance (see 3.14). Capacitors shall be tested in accordance with method 302 of MIL-STD-202. The following details shall apply:

- a. Test potential - Rated voltage.
- b. Special conditions - If a failure occurs at a relative humidity above 50 percent, the insulation resistance may be measured again at any relative humidity less than 50 percent.
- c. Points of measurement - Between the mutually insulated points.

4.6.11 Destructive physical analysis (see 3.4.1 and 3.15). Capacitors shall be examined as specified in EIA Standard RS-469 and in accordance with table XII.

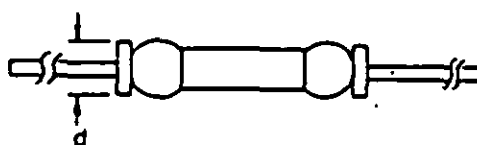
4.6.12 Terminal strength (see 3.16).

4.6.12.1 Terminal strength (leaded capacitors) (see 3.16). Capacitors shall be tested in accordance with method 211, MIL-STD-202. The following details and exceptions shall apply:

- a. Test condition - A.
 - (1) Method of holding - Capacitors shall be held by one terminal and the load shall be applied gradually to the other terminal.
 - (2) Applied force - 2 ± 1 kilograms.
- b. Test condition - C, applicable to radial-lead units only.
- c. Test condition - D, applicable to axial-lead units only.
- d. Examination after test - Capacitors shall be visually examined for evidence of loosening or rupturing of the terminals.

4.6.12.2 Terminal strength (nonleaded capacitors) (see 3.16). Capacitors shall be tested in accordance with method 211 of MIL-STD-202. The following details and exceptions shall apply:

- a. Test condition A.
 - (1) Capacitors shall have nail head, lead wire (.020 to .025) attached as shown on figure 5, prior to pull test.
 - (2) Method of holding - Capacitors shall be held by one terminal and the load shall be applied gradually to the other terminal.
 3. Applied force - See figure 5.
- b. Examination after test - Capacitors shall be visually examined for evidence of loosening or rupturing of the terminals. Breakage of lead wire or solder interface, which does not expose ceramic, shall not constitute a failure.



Style	Nail head diameter	Applied force
CKS51	.040 \pm .005	1 Kg \pm .1
CKS52	.040 \pm .005	1 Kg \pm .1
CKS53	.045 \pm .005	2 Kg \pm .2
CKS54	.045 \pm .005	2 Kg \pm .2

FIGURE 5. Lead attachment for chip pull test.

4.6.13 Solderability (see 3.17).

4.6.13.1 Solderability for leaded capacitors (see 3.17.1). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. Two terminations shall be tested.

4.6.13.2 Solderability for nonleaded capacitors (see 3.17.2). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. The following details and exceptions shall apply:

- a. Solder shall be Sn62 in accordance with QY-S-571.
- b. Each chip capacitor shall be immersed in molten solder to a depth of .020 \pm .010, \pm .000 inch.
- c. Number of terminations to be tested - 2.
- d. Examination of terminations shall be in accordance with 3.17.2. In case of dispute, the percent coverage with pinholes or exposed termination material shall be determined by actual measurement in these areas, as compared to the total area.

4.6.14 Resistance to soldering heat (see 3.18).

4.6.14.1 Resistance to soldering heat for leaded capacitors (see 3.18.1). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details and exceptions shall apply:

- a. Capacitors shall be immersed using procedure 1.

- b. Depth of immersion in the molten solder - To within 0.050 inch from the capacitor body (see figure 6).
- c. Test condition - 3, except that the immersion duration shall be 20 ± 1 seconds.
- d. Cooling time prior to measurement after test - 10 ± 1 , -0 minutes.
- e. Measurements before test - Capacitance, DF and IR at 25°C shall be measured and recorded as specified in 4.6.7, 4.6.8, and 4.6.10.
- f. Measurements after test - Capacitors shall meet the requirements of 3.18.1, capacitance, dissipation factor, and insulation resistance at 25°C shall be measured and recorded as specified in 4.6.7, 4.6.8, and 4.6.10, respectively.

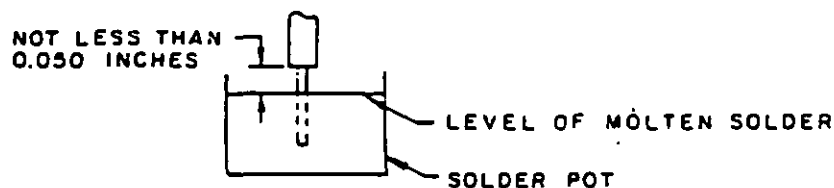


FIGURE 6. Depth of immersion in molten solder.

4.6.14.2 Resistance to soldering heat (nonleaded capacitors) (see 3.18.2). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details shall apply:

- a. Capacitors shall be immersed using procedure 1, two times.
- b. Test condition - B, except the solder temperature shall be $230^\circ \pm 5$, -0°C and the duration shall be 5 ± 1 , -0 seconds.
- c. Cooling time prior to measurement after test - 10 minutes minimum and up to 24 hours maximum.
- d. Measurements before test - Capacitance, dissipation factor, and insulation resistance at 25°C shall be measured and recorded as specified in 4.6.7, 4.6.8, and 4.6.10, respectively.
- e. Examination and measurement after test - Capacitors shall meet the requirements of 3.18.2. Capacitance, dissipation factor, and insulation resistance at 25°C shall be measured and recorded as specified in 4.6.7, 4.6.8, and 4.6.10, respectively.

4.6.15 Voltage-temperature limits (see 3.19). The temperature of each capacitor shall be varied as specified in table XV. Capacitance measurements shall be made at the frequency and voltage specified in 4.6.7. The dc rated voltage specified in table XV shall be maintained on the capacitor during steps E to G inclusive. Capacitance measurements shall be made at each step specified in table XV and at five intermediate temperatures between steps B and G to establish a true characteristic curve. Capacitors shall be kept at each temperature until temperature equilibrium is attained.

4.6.15.1 Voltage-temperature limits for quality conformance inspection. Capacitance measurements shall be made as specified in 4.6.7 except that the measurements shall be made only for steps C, D, E, and G of table XV.

TABLE XV. Voltage-temperature limit cycle.

Step	Voltage, dc	Temperature °C
A	none	+25 ±2
B	none	-55 ±2
C 1/	none	+25 ±2
D	none	+125 ±2
E	rated	+125 ±2
F	rated	+25 ±2
G	rated	-55 ±2

1/ Reference point.

4.6.16 Moisture resistance (see 3.20).

4.6.16.1 Humidity, steady state, low voltage. Capacitors shall be tested in accordance with method 103, condition A of MIL-STD-202. The following details and exceptions shall apply:

NOTE: At no time during test shall voltage greater than 1.5 volts be applied to any capacitor under test.

- Initial measurements - Not applicable.
- Tests - Capacitors shall be subjected to an environment of 85°C with 85 percent relative humidity for 240 hours minimum. Cycling shall not be performed. A dc potential of 1.5 volts maximum shall be applied continuously through a 100 kilohm resistor.
- Final measurements - Upon completion of above tests, remove capacitors from chamber and allow to dry and stabilize at 25°C before performing insulation resistance (IR) through a 100 kilohm resistor at 1.5 V maximum, capacitance and dissipation factor in accordance with paragraph 3.11, 3.12, and 3.14.
- Visual examination - After final measurements, the capacitors shall be examined for evidence of mechanical damage and obliteration of marking.
- Leads may be attached to chip capacitors for mounting and loading purposes. Mechanical loading is acceptable.

4.6.16.2 Moisture resistance normal voltage. Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following detail and exceptions shall apply:

- Initial measurements - Not applicable.
- Number of cycles - 20 continuous cycles.
- Tests - During the first 10 cycles only, a dc potential of 50 volts shall be applied across the capacitor terminals. Once each day, a check shall be performed to determine whether a capacitor has shorted. Vibration cycle of step 7b shall not be performed.
- Final measurement and examination - Upon completion of step 6 of the final cycle, capacitors shall be measured for capacitance, dielectric withstanding voltage, and insulation resistance as specified in 4.6.7, 4.6.9, and 4.6.10, respectively.
- Leads may be attached to chip capacitors for mounting and loading purposes. Mechanical holding is acceptable.
- IR at 1.5 volts shall be calculated and compared to specified value at rated voltage. IR shall not be less than 50 percent of the initial 25°C requirements.

4.6.17 Vibration, high frequency (leaded capacitors only) (see 3.21). Capacitors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exceptions shall apply:

- a. **Mounting** - Capacitors shall be rigidly mounted on a mounting fixture by the body. The leads shall be secured to rigidly supported terminals, so spaced that the length of each lead from the capacitor is approximately 0.375 inch when measured from the edge of the supporting terminals. Leads shall be within 15° of being parallel. When securing leads, care shall be taken to avoid pinching the leads. The mounting fixture shall be so constructed as to preclude any resonances within the test range. An examination of the mounting fixture shall be made on a vibrator. If any resonant frequencies are observed, adequate steps must be taken to damp the structure.
- b. **Electrical load conditions** - During the test, a dc potential equal to 125 percent of the dc rated voltage (see 3.1) shall be applied between the terminals of the capacitor element under test.
- c. **Test condition** - E (50's), except frequency range of 10 and 3,000 Hz.
- d. **Duration and direction of motion** - Equal amounts of time in each of three mutually perpendicular planes (total of 8 hours).
- e. **Measurements during vibration** - During the last cycle in each direction, an electrical measurement shall be made to determine intermittent contacts of 0.5 ms or greater duration or open or short-circuiting.
- f. **Examination after vibration** - Capacitors shall be visually examined for evidence of mechanical damage.

4.6.18 Resistance to solvents (see 3.22). Capacitors shall be tested in accordance with method 215 of MIL-STD-202. The following details shall apply:

- a. The marked portion of the capacitor body shall be brushed.
- b. The number of sample units to be examined shall be as specified in table VII.
- c. Capacitors shall be visually examined for evidence of mechanical damage and obliteration of marking.

4.6.19 Life (at elevated ambient temperature) (see 3.23). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exceptions shall apply:

- a. Distance of temperature measurements from specimens, in inches, not applicable.
- b. Test temperature and tolerance - $+125^{\circ} \pm 4$, -0°C .
- c. Capacitors shall be subjected to the voltage and circuit specified in 4.6.6.2.
- d. Test duration - 4,000 hours for qualification and 1,000 hours for group B.
- e. **Measurements during and after exposure** - At the conclusion of 250, 1,000, 2,000, and 4,000 hours and while the capacitors are at the applicable high-test temperature, the insulation resistance shall be measured as specified in 4.6.10. At the option of the manufacturer, the units may be immediately transferred (period of transfer not to exceed 15 minutes) to another chamber maintained at the same temperature for the purpose of measuring insulation resistance. The insulation resistance measurement shall be made only after the units have stabilized at the test temperature. The capacitors shall then be returned to the inspection conditions specified in 4.3 and shall be visually examined for evidence of mechanical damage and obliteration of marking; insulation resistance, capacitance and dissipation factor, shall be measured as specified in 4.6.7, 4.6.8, and 4.6.10, respectively.

TABLE XVI. Life test.

Lot size	Minimum sample size	250-4,000 hours	
		Accept	Reject
1 - 1,200	25	0	1
1,201 - 10,000	80	1	2

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-C-39028.

6. NOTES

6.1 Ordering data. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. Title, number, and date of the applicable specification sheet, and the complete part number (see 3.1).
- c. Lead length, if different from that specified (see 3.1). Lead lengths may be a minimum of one inch long for use in tape and reel automatic insertion equipment, when specified.

6.2 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of the contractors is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is the George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Code EGO2, Marshall Space Flight Center, Alabama 35812; however, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), Dayton, Ohio 45444. Application for qualification tests shall be made in accordance with SD-6 "Provisions Governing Qualification" (see 6.2.1).

6.2.1 Copies of SD-6 "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

6.3 Case insulation. It is not intended that the case insulation be subjected to sustained voltage in excess of 150 percent of the dc rated voltage of the capacitor. Supplementary insulation should be provided where the case may come in contact with higher voltage.

6.4 Changes from previous issue. Asterisks are not used in these revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Air Force - 19
NASA - NA

Preparing activity:
NASA - NA

Review activities:
Army - ER
Navy - EC
Air Force - 11
DLA - ES

(Project 5910-1417)

Agent:
DLA - ES

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PROCEDURE FOR QUALIFICATION INSPECTION

A10. SCOPE

A10.1 Scope. This appendix details the procedure for submission of samples, with related data, for qualification inspection of capacitors covered by this specification. The procedure for extending qualification of the required sample to other capacitors covered by this specification is also outlined herein. There shall be no combining of styles, operating voltage or characteristic, each shall be qualified separately. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

A20. Applicable documents. This section is not applicable to this appendix.

A30. SUBMISSION

A30.1 Qualification based upon similar established reliability (ER) style. The manufacturer seeking qualification for a CKS style who is qualified to "R" failure rate level of a similar ER style (see table XVII) shall submit to test the highest capacitance value in each voltage rating and characteristic. The qualification sample shall consist of 44 pieces of each division above for leaded styles and 92 pieces of each division for nonleaded styles. The four 44 piece samples will be the total 176 piece required for leaded style qualification per table VII. The two 92 piece samples will be the total 184 pieces required for nonleaded style qualification per table VII.

TABLE XVII. Similar ER styles.

CKS style	Similar style	CKS style	Similar style
CKS05-BP	CCR05	CKS14-BP	CCR77
CKS05-BX	CKR05	CKS14-BX	CKR14
CKS06-BP	CCR06	CKS15-BP	CCR78
CKS06-BX	CKR06	CKS15-BX	CKR15
CKS07-BP	CCR07	CKS16-BP	CCR79
CKS07-BX	-----	CKS16-BX	CKR16
CKS11-BP	CCR75	CKS26	CKR06
CKS11-BX	CKR11	CKS51	CDR01
CKS12-BP	CCR76	CKS52	CDR02
CKS12-BX	CKR12	CKS53	CDR03
		CKS54	CDR06

A30.2 Qualification not based upon similar established reliability styles. A sample of the size required in table VII, of the highest capacitance value in each voltage rating and characteristic in each style for which qualification is sought shall be submitted. For example, style CRS05 shall require 704 total sample units to qualify for the entire style.

A30.3 Test data. When examinations and tests are to be performed at a Government laboratory, prior to submission, all sample units shall be subjected to all of the examinations and tests indicated as nondestructive in table VII. Each submission shall be accompanied by the test data obtained from these examinations and tests. The performance of the destructive tests by the supplier on a duplicate set of sample units is encouraged, although not required. All test data shall be submitted in duplicate.

A30.4 Certification of material. When submitting samples for qualification, the contractor shall submit certification, in duplicate, that the materials used in his components are in accordance with the applicable specification requirements and the baseline documentation.

A30.5 Description of items. The manufacturer shall submit a detailed description of the capacitors being submitted for inspection, including body, electrode material, terminal leads, etc.

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A40 EXTENT OF QUALIFICATION

A40.1 Restrictions upon qualification. Capacitance-range qualification shall be restricted to values equal to and less than the capacitance value submitted. Capacitance-tolerance qualification will be restricted to tolerance equal to and wider than the tolerance submitted. DC rated voltage qualification will be restricted to that submitted. Operating temperature range and voltage temperature limit qualification shall be restricted to that submitted.

PROCEDURES FOR THE PRODUCT AND QUALITY AUDIT

810. SCOPE

810.1 Scope. This appendix provides procedures to the Product and Quality Audit team for the auditing of manufacturers supplying to this specification. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

820. Applicable documents. This section is not applicable to this appendix.

830. INSTRUCTIONS

830.1 Baseline document. The manufacturer shall complete the baseline document and submit the required information to the qualifying activity prior to scheduling the Product and Quality Audit. It is not intended that the manufacturer submit proprietary information. Each manufacturer shall provide a detailed process flow chart which shall include, as a minimum:

- a. All major process steps and inspection points by descriptive title, document number and revision.
- b. The identification of all critical manufacturing and inspection steps as determined by the manufacturer in conjunction with the audit team at the time of baseline approval.

830.1.1 Changes to baseline. The audit team shall compare the latest baseline document to the previous baseline document to assure all changes have been submitted to the qualifying activity and have been approved.

- a. Minor changes. Any subsequent departure from the approved flow chart (i.e., additions or deletions) or changes to the revision status of those processes or inspections are allowed, provided they do not violate the changes prohibited by Section b (major changes). These minor changes shall be described in general terms to the audit team during subsequent audits. This action shall result in an update of the baseline document.
- b. Major changes. No changes (i.e., substitutions) shall be allowed in the following areas without prior review and approval of the qualifying activity. In these areas partial or total requalification may be required as determined by the qualifying activity.
 - (1) Dielectric formulation
 - (2) Electrode formulation
 - (3) End termination formulation
 - (4) Solder formulation
 - (5) Lead wire material
 - (6) Encapsulation material
 - (7) Capacitor design (i.e., dielectric thickness, number of electrodes, chip size, except as permitted by the baseline).
 - (8) Basic buildup system

830.2 Audits. An initial audit and subsequent periodic audits (every year or as deemed necessary) shall be performed by the qualifying activity. The audit shall include, but not be limited to, all of the items on the checklist. The results of any additional items that are assessed shall be added to the checklist for record purposes.

830.2.1 Duties of the audit team.

- a. The audit team shall review the baseline document for adequacy and completeness prior to the audit of the manufacturer and should be used as a baseline/reference during the course of the audit.
- b. The audit team shall verify that all measuring and test equipment is functioning and calibrated. They shall also verify that test measuring procedures and equipment are sufficiently accurate for the required test.

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- c. The audit team shall typically sample check twelve months of records for the item being certified. In addition, the location of the equipment and the adequacy of the operating procedure shall be checked and whenever practical, operations utilizing the equipment and procedures witnessed.
- d. The audit team shall insure that adequate documentation, trained personnel, equipment, and visual aids are available to perform the inspections specified in figure B1.

Check - item	Insp.	Satisfactory
a. Verification of MIL-STD-790 requirements		
b. Flow chart		
1. Key processes identified with revision		
2. Key inspection identified with revision		
3. Non-proprietary documents reviewed		
4. Screens/inspection points identified		
c. Baseline - shall describe as a minimum the following:		
1. Capacitor design by part number indicating the following with the necessary tolerance defined:		
dielectric type		
dielectric thickness		
number of electrodes		
chip size		
2. Basic electrode formulation identification		
3. Basic end termination formulation identification		
4. Solder formulation identification		
5. Lead wire		
6. Encapsulation material identification		
7. Internal visual prior to encapsulation		
d. Lot control plan (para. 4.5.2.1)		
e. Traceability plan		
f. Training plan for QC personnel		
g. Non-destructive test plan		

FIGURE B1. Certification check list.

NONDESTRUCTIVE PHYSICAL ANALYSIS

C10. SCOPE

C10.1 Scope. This appendix specifies the procedures for the nondestructive internal examination of CKS ceramic capacitors. The test procedures for both neutron radiographic inspection (NRI) and ultrasonic examination are included. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

C20. APPLICABLE DOCUMENTS

C20.1 Other publications. The following document forms a part of this specification to the extent specified herein.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E-545 - Determining Image Quality in Thermal Neutron Radiographic Testing.

C30. NEUTRON RADIOGRAPHIC INSPECTION (NRI)

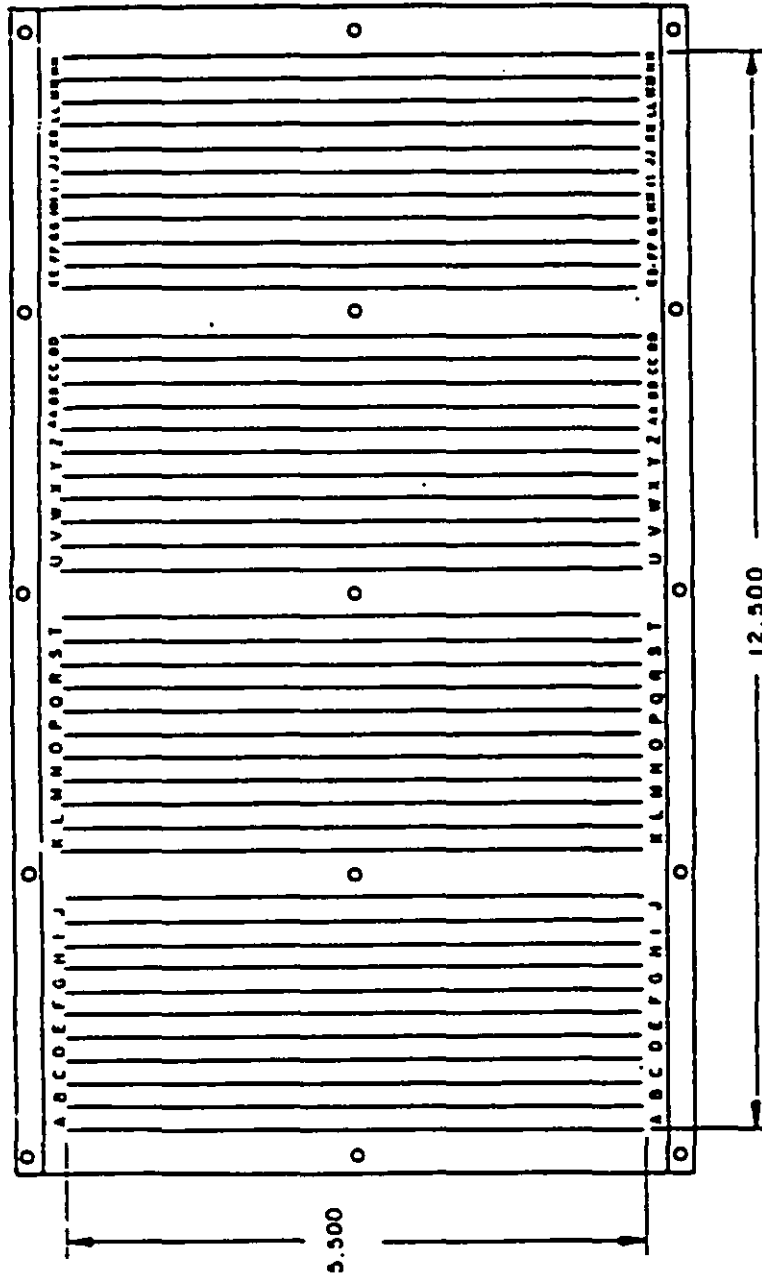
C30.1 Purpose. This section specifies procedures and practices necessary for the successful neutron radiographic inspection (NRI) of ceramic capacitors for delaminations.

NOTE: Neutron radiographic inspection of ceramic capacitors for small delaminations (in the order of .001" or less) required special fixturing and techniques to assure state-of-the-art detection capacity. The prime requirement for this inspection is careful orientation of the plane of delamination parallel to the axis of the neutron beam.

C30.2 Requirement. Each lot, if more than one (1) lot of capacitors is tested in any one (1) fixture, calibrated samples shall be required for each lot.

C30.3 Apparatus.

- a. A neutron radiographic facility that shall produce a beam comprised basically of unscattered, thermalized neutrons. Gamma radiation, scattered neutrons and fast neutrons shall be minimized. As a minimum, the beam composition shall produce a radiograph with a ASTM E-545-75 index of N75-15-11. Maximum gamma content will be 2%. The neutron beam shall have an L/D of at least 250.
- b. Facility fixturing shall provide for alignment of the capacitor fixture relative to the beam within 0.4°.
- c. Radiographic film shall be Eastman Type SR-54 or equivalent.
- d. Copy film shall be Eastman RP/D or equivalent.
- e. Film holder shall be a vacuum cassette with a gadolinium metal converter. Cleanliness is essential to high-quality neutron radiography. The radiography cassettes shall be cleaned prior to each production run. The film shall be loaded into the cassette in a laminar-flow-ultra-clean bench or equivalent.
- f. Capacitor mounting fixture shall be rugged enough to withstand air shipment while securely holding the capacitors in proper orientation. Drawings for suitable fixtures are shown in figures C1 and C2. The fixture shall be made of 6061-T6 aluminum and as thin and uniform in thickness as practical in the direction of the neutron beam. Also included in this fixture are aluminum keys and rubber spacer strips. The aluminum keys shall fit tightly in the fixture to assure correct alignment of the capacitors. The rubber spacer strips have .094, .125, .188, and .250 inch square cross sections and are used to provide a snug fit of various sized capacitors in the fixture. This fixture must be maintained clean with no tape or gum residue left in the areas of interest prior to loading the capacitors.
- g. Beam purity indicators and sensitivity gages per ASTM E-545. In addition, a defective part standard may be included as an indicator.
- h. Radiographic viewer shall be provided capable of resolving 0.0254 mm (0.001 in.).



NOTE: Dimensions are applicable to the active portion (subject to exposure) only.

FIGURE C1. Typical N-ray fixture.

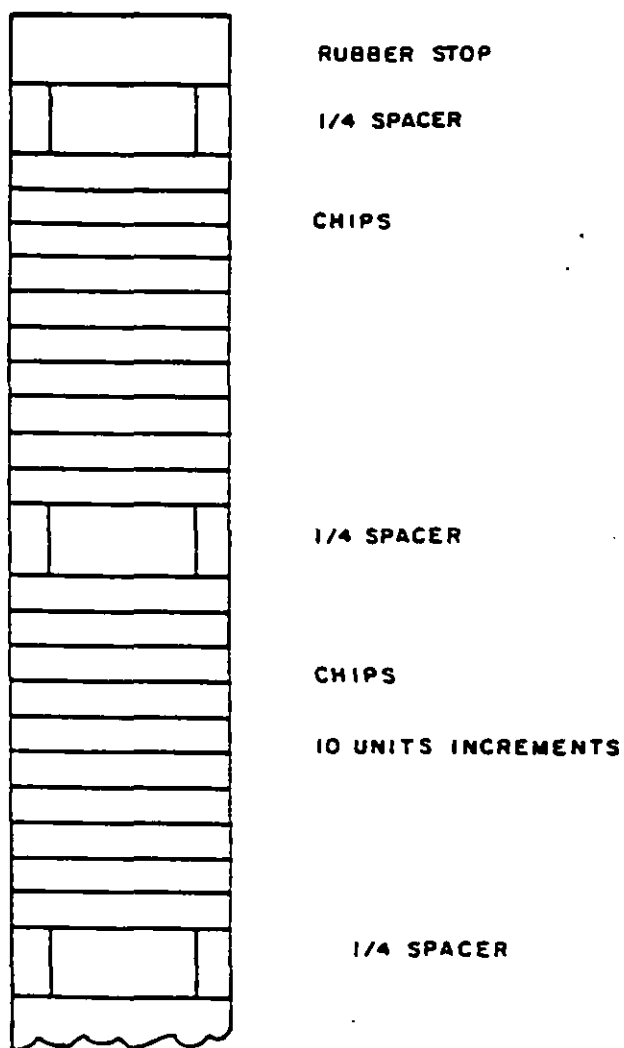


FIGURE C2. Loading tunnel.

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- i. Two (2) capacitors previously determined to be made of the same dielectric material and size of the parts under test shall be added to the lot for testing.
- j. Neutron sensitive labeling shall be used for identification of the capacitors in the fixturing. This material, which is imprintable with a typewriter, is available from the neutron radiographic facility.

C30.4 Procedure. The neutron exposure time shall be adjusted to achieve a film background optical density between 2.0 and 3.0. The lower density shall be used on low neutron attenuation capacitors, the higher density on high attenuation capacitors.

C30.4.1 Mounting and views. The capacitors shall be mounted such that the electrodes are parallel both to the neutron beam and to the long axis of the fixture. Alignment keys are required to assure that capacitors remain in a vertical configuration. The alignment keys also provide a visual aid to the film interpreter by providing reference points for counting capacitors. Additionally, rubber spacers may be required to fill gaps and assure that capacitors are held tightly against the alignment keys.

C30.4.2 View 3, critical alignment. Each capacitor shall be placed such that the electrodes of the capacitor shall be parallel ($\pm 0.6^\circ$) to the neutron beam and their longitudinal axis normally shall be perpendicular to the neutron beams. An aluminum key spacer every ten (10) capacitors provides a realignment surface in the event of uneven coatings on capacitors. A row of capacitors shall not be more than four (4) inches in length to minimize the effect of the angle of divergence of the neutron beam.

C30.4.3 Radiographic quality standard. ASTM beam purity indicators and sensitivity gages shall be radiographed in accordance with current recommendations or ASTM E-545-75. In addition, standard defect parts shall also be placed on the plate to be radiographed. These devices shall be used to assure a quality neutron radiograph. In those cases where no room is allowed for the BPI or sensitivity gage, the performing facility shall certify that the required quality level can be met with the exposure conditions used. If required, a verification blank radiograph shall be supplied, using identical exposure conditions with the BPI and sensitivity gage.

C30.4.4 Film. Each film shall normally bear the following minimum identification typed on neutron absorbing material.

Name of performing facility
Date
Film number
Organization for whom test is being performed
Part titles and serialization
User mounted and/or labeled trays will be so noted on the radiograph

C30.4.5 Processing. The radiographic film manufacturer's recommended procedure shall be used to develop the exposed film, and film shall be processed so that it is free of processing defects such as fingerprints, scratches, fogging, chemical spots, blemishes, etc.

Furthermore, no apparent film flaws shall be present in a critical area of the components. Should one occur, the radiograph shall be redone to prove that the flaw is in the film and not in the part. Also, since gadolinium conversion screens with zero surface defects are unavailable, a limited number of bright specks due to these flaws are allowable if positively identified and correlated to a known flaw in the screen.

C30.5 Operating personnel. Personnel who will perform radiographic inspection shall have training in radiographic procedures and techniques so that defects revealed by this method can be validly interpreted and compared with applicable standards. The following minimum vision requirements shall apply for visual acuity of personnel inspecting film.

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- a. Distant vision shall equal at least 20/30 in both eyes, corrected or uncorrected.
- b. Near vision shall be such that the operator can read Jaeger type No. 2 at a distance of 16 inches, corrected or uncorrected.

C30.6 Inspection of radiographs. Utilizing the equipment specified herein, radiographs shall be inspected to determine that each device conforms to this standard and defective devices shall be rejected. Interpretation of the radiograph shall be made under low ambient light level conditions without glare on the radiographic viewing surface. The radiographs shall be examined on a suitable illuminator with variable intensity or on a viewer suitable for radiographic inspection on projection type viewing equipment. The radiograph shall be viewed at a magnification between 6X and 25X. Viewing masks may be used when necessary. Any radiograph not clearly illustrating the features in the radiographic quality standards is not acceptable and another radiograph of the devices shall be taken.

C30.7 Reports and records. Appropriate information (number tested, number failed) from scanning results shall be recorded on the chip lot traveler. The scanner printout sheets shall be identified with the chip lot number, size, voltage rating and capacitance value and place on file.

C40 ULTRASONIC EXAMINATION TEST METHODS AND REQUIREMENTS

C40.1 Equipment. The test equipment shall be in accordance with the list below or its equivalent.

Equipment

- a. Ultrasonic scanner US450 series *
 - b. Pulser/receiver unit model 50S *
 - c. Lab scanner model 450 *
 - d. 25 MHz Transducer model 57 AH006 *
 - e. Sectioning equipment EIA Standard RS-469.
 - f. Glass plate
 - g. Plexiglass plate
 - h. Capacitor chips known to be good (absence of delamination and cracks)
 - i. Capacitor chips known to be defective (with delaminations)
- * Manufactured by Automation Industries Inc., Sperry Products Division, Subsidiary of General Cable.

C40.2 Requirements. Capacitor chips determined to be good after testing and when sectioned in accordance with paragraph 4.6.2 must meet the DPA requirements of paragraph 4.6.2.

C40.2.1 Lots tested. Only one (1) production lot of parts shall be scanned at one time.

C40.2.2 Calibration samples. Two (2) previously determined bad capacitors of the same dielectric material and size of the parts under test shall be added to the lot for testing.

C40.3 Initial setup procedure. The initial setup procedure is as follows:

- a. Equipment shall be turned on and warmed up for fifteen (15) minutes, minimum.
- b. The tank shall have a water depth of $6 \pm .250$ inch. 175 ± 5 ML of wetting agent shall be added to the tank.
- c. Chips shall be placed in identifiable rows on the plexiglass and shall not be touching each other. The plexiglass tray must be level and perpendicular to the transducer head axis. The tray shall be checked after it is in the tank to assure no air bubbles are trapped under the chips or tray.

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C40.4 Operating procedures. The chip image return, and gate alarm setting shall be adjusted each time the equipment is turned off and on the first tray of chips to be scanned per lot. Adjustments shall be in accordance with the test facilities operating instructions. The adjustments shall clearly confirm the good and bad calibration samples. These parts shall be easily identifiable from the remaining of the lot under test.

C40.5 Qualification. Each test facility shall have a responsible person who has successfully completed a nondestructive testing course given by the manufacturers of the ultrasonic test equipment. The ultrasonic test equipment shall not be operated by anyone who has not been certified and instructed in the use of ultrasonic testing by the designated person. The responsible person shall prepare a test method that describes the general procedures, requirements and techniques for ultrasonic scanning of ceramic chips.

C40.6 Equipment usage. Testing shall be done in accordance with the test equipment manufacturers instructions and the test facilities operating procedures. The tank must be completely drained, cleaned and refilled at least once a month. NOTE: Anytime the tank is drained and refilled, the transducer lense must be checked to ensure bubbles have not been trapped.

- a. The scanners (XY recorder) shall be activated and the printout of the calibration samples shall be compared against the scanner's "0" scope. If correlation for the calibration samples is obtained with setting of C40.4, the entire lot can be scanned with that setting.
- b. Any questionable scope results shall reject the chip under question.

C40.7 Documentation. Appropriate information (number tested, number failed) from scanning results shall be recorded on the chip lot traveler. The scanner printout sheets shall be identified with the chip lot number, size, voltage rating and capacitance value and placed on file.

VISUAL INSPECTION CRITERIA FOR CHIP CAPACITORS

D10. SCOPE

D10.1 Scope. This appendix specifies the visual inspection criteria for chip capacitors. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

D20. Applicable documents. This section is not applicable to this appendix.

D30. PROCEDURES FOR INSPECTION AND REJECTION

D30.1 Method of inspection. Each device shall be examined under 10 power magnification to determine compliance with the requirements specified herein.

D30.2 Rejection criteria. Devices that deviate from the material, design or construction requirements specified or that fail to meet the following requirements shall be unacceptable:

D30.2.1 Termination metallization.

- a. End terminals shall be completely covered. Pinholes less than or equal to 0.005 inch in diameter are permitted (maximum of three pinholes in each surface area).
- b. Gaps in the metallization band shall only be acceptable if the metallization band is not less than the minimum metallization band requirement specified (see figure D1).
- c. Metallized edges shall not be reduced to less than 90% due to chipping or metallizing process (see figure D2).
- d. There shall be no excess metallization or solder tear which violates the minimum pad separation (see figure D3).
- e. There shall be no foreign material visible adhering to the solder, or voids in the solder revealing greater than 10% of the base metallization (see figure D4).

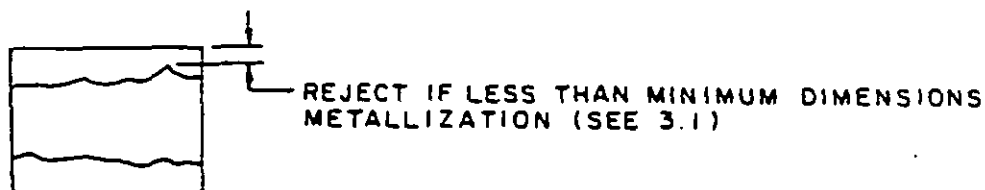


FIGURE D1. Metallization band gaps.

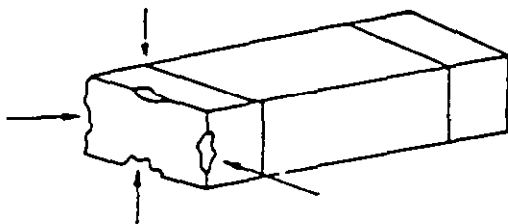


FIGURE D2. Metallization band chipping.

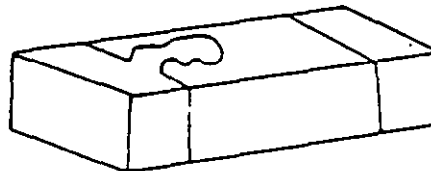


FIGURE D3. Excessive metallization.

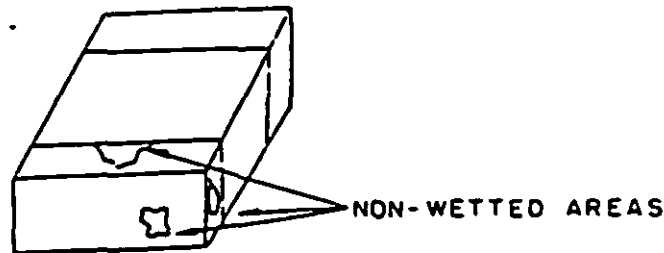


FIGURE D4. Solder defects.

D30.2.2 Ceramic surface examination.

- a. There shall be no cracks (see figure D5).
- b. There shall be no delamination of ceramic layers. A delamination is the separation of ceramic layers (usually observed on sides). (See figure D6.)
- c. Striations are unacceptable (see figure D6).
- d. Edge chip-outs shall not extend to within 0.003 inches of an electrode. An edge chip-out is any region where material has been removed as a result of a fracture (see figure D7).
- e. Rough edges shall be permitted provided they are within the allowable chip-out region as specified in figure D7.
- f. Lips, flared edges or irregular shapes shall not exceed limits specified in figure D8.
- g. There shall be no fused dust or excess material on external surface that prevents a chip from lying flat or protrude more than 0.003 inch out of a surface.
- h. There shall be no raised surfaces, bubbles, or blisters greater than 0.002 inch (usually found on top and bottom). (See figure D9.)
- i. When compared to a flat surface, the clearance (warpage) at the center of the chip shall be less than 5% of the length dimension (see figure D10).
- j. A pinhole is a circular hollow or cavity no larger than 0.002 inch in diameter (see figure D11). They are unacceptable if they exceed this size.
- k. There shall be no holes (voids) that expose electrode plates (see figure D12).
- l. The marking shall be legible and complete (see figure D13).

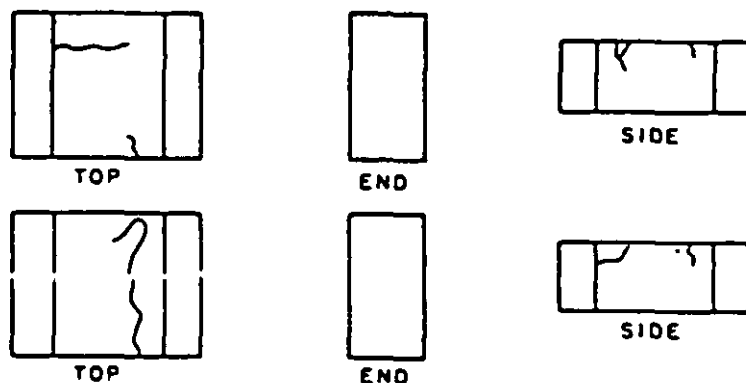


FIGURE D5. Cracks.

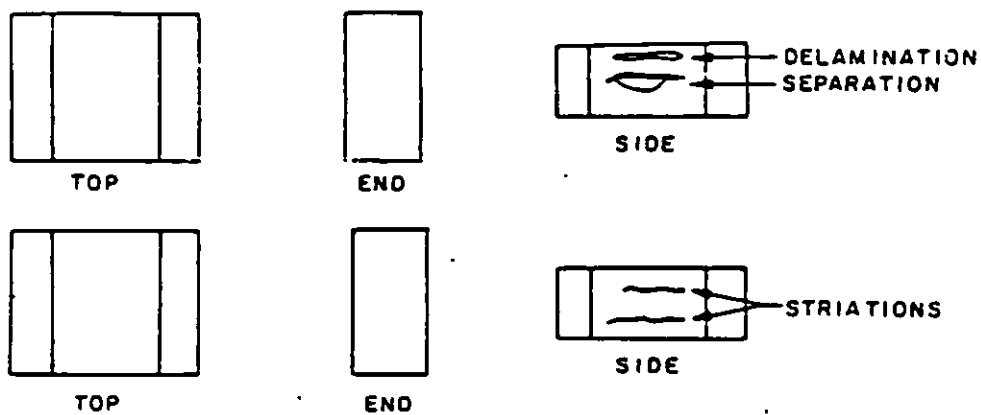


FIGURE D6. Delaminations and striations.

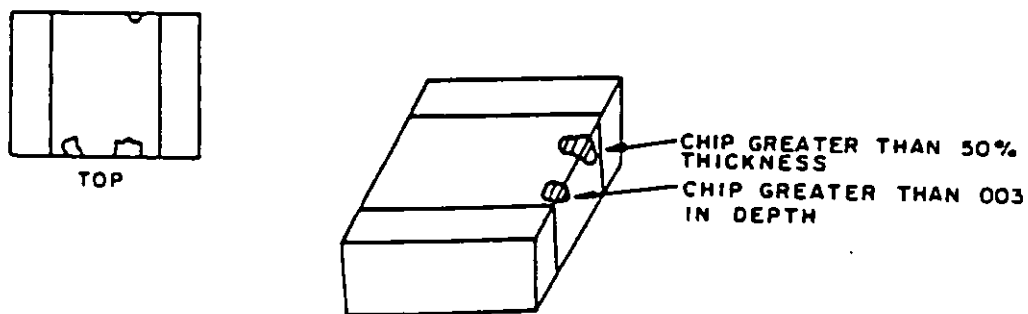
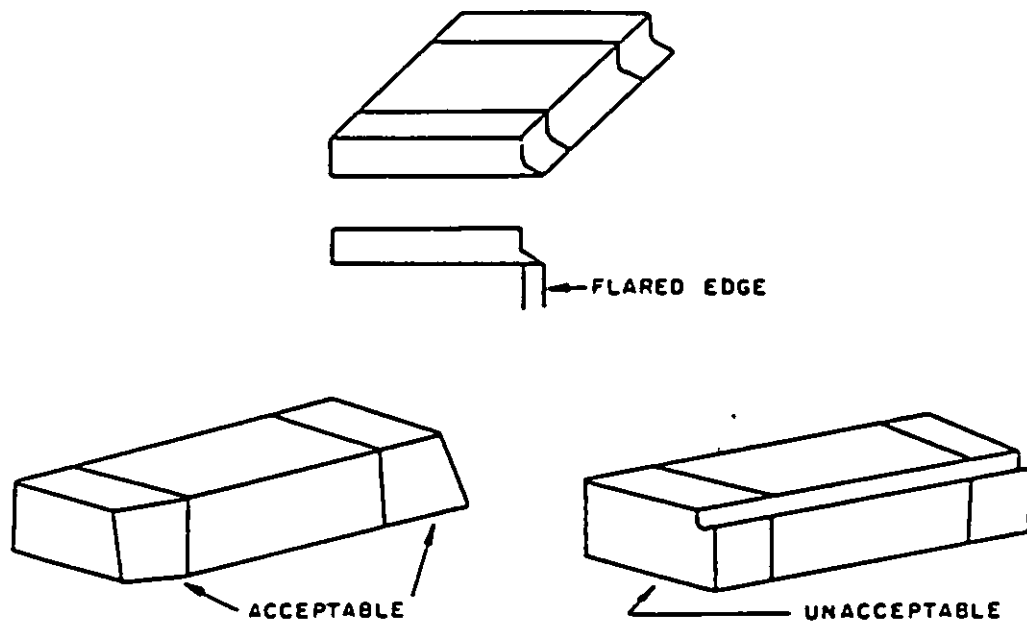


FIGURE D7. Chip-outs.



IRREGULAR SHAPES WHICH DO NOT EXPOSE ELECTRODES

FIGURE D8. Unacceptable lips, flared edges or irregular shapes.

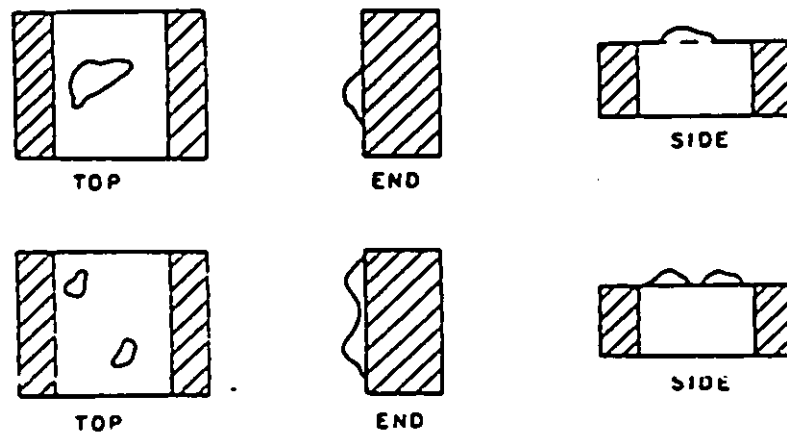


FIGURE D9. Raised surfaces, bubbles and blisters.

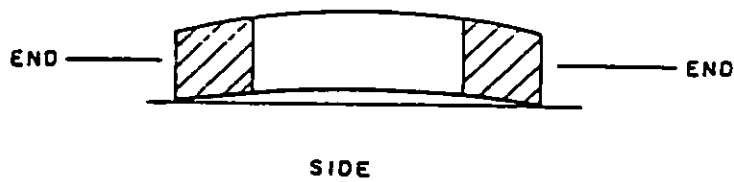


FIGURE D10. Warpage.

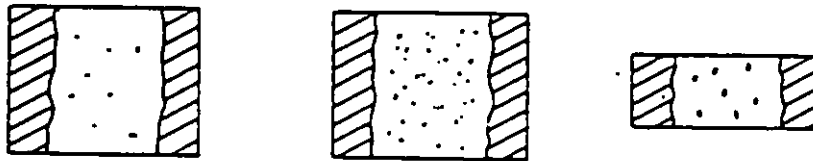


FIGURE D11. Pinholes.

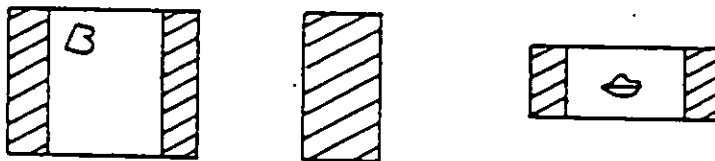


FIGURE D12. Voids.

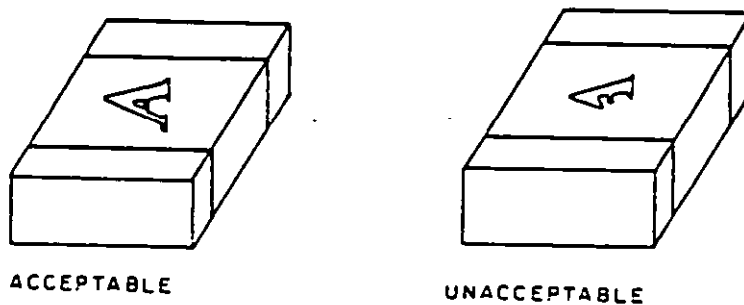


FIGURE D13. Marking.

LEAD PULL

E10. SCOPE

E10.1 Scope. This appendix specifies special test procedures and methods for CKS ceramic capacitors. Details for testing of axial and radial leaded capacitors prior to molding or encapsulation is included. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

E20. Applicable documents. This section is not applicable to this appendix.

E30. EQUIPMENT

E30.1 Gage and test stand. The test equipment used shall be in accordance with the list below or its equivalent.

- a. Chantillon push-pull gauge, model DPP-25.
- b. Chantillon test stand, model LTC or equivalent.

E40. TEST METHOD

E40.1 Radial devices. Firmly clamp the body of the capacitor into the test stand. Gradually apply an ever increasing force to one lead at a time in the direction of the leads (see figure E1) until rupture occurs. Record the force for both leads.

E40.2 Axial devices. Firmly clamp one lead into the test stand. Gradually apply an ever increasing force in the direction of the leads (see figure E1) until rupture occurs. Now clamp the body of the device and pull the remaining good lead in the direction of lead until rupture occurs. Record the stress level for both leads.

E40.3 Minimum rupture force. Minimum rupture force shall be in accordance with table XIII.

E50. REJECTION CRITERIA

E50.1 Defects. If one (1) failure occurs, additional samples per table XII shall be retested with zero failures. If two (2) failures occur the lot shall be rejected.

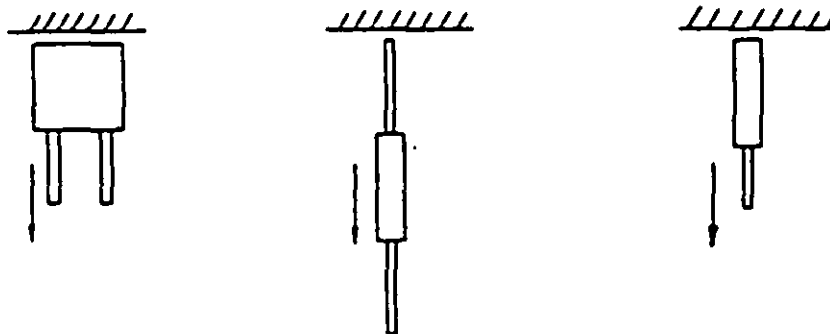


FIGURE E1. Lead-pull direction.

RADIOGRAPHIC INSPECTION

F10. SCOPE

F10.1 Scope. This appendix specifies procedures and practices necessary for radiographic inspection of ceramic capacitors during group A acceptance inspection. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

F10.2 Facilities. Radiographs of the capacitors may be made by the capacitor manufacturer or a suitable independent laboratory. In either case, facilities, equipment, personnel, and techniques shall be in accordance with the requirements specified herein.

F10.3 Responsibility for inspection. The capacitor manufacturer shall perform the inspection of the radiograph films and acceptance/rejection of the capacitors.

F20. Applicable documents. This section is not applicable to this appendix.

F30. EQUIPMENT

F30.1 Dimensions. The dimensional values upon which these requirements are based were developed using the U. S. system. The metric equivalents were obtained by direct conversion based upon 1 inch = 25.4 mm. Where such equivalents do not correspond to a standard metric size, the closest standardized metric equivalent size may be used.

F30.2 Radiography. The X-ray equipment shall have sufficient voltage range to produce radiographs in accordance with this document. The equipment shall have a focal spot of 3.5 millimeters (mm) or less and shall maintain a sharply defined image at a focal film distance of 30 to 60 inches (76.20 to 152.40 centimeters).

F30.3 Exposure factors. The X-ray exposure factors shall be selected to achieve maximum image detail within the sensitivity requirements. The film shall be exposed in accordance with the following requirements:

- a. X-ray voltage - lowest voltage possible.
- b. H and D film density - 1.5 to 3.0.
- c. Milliamperage and time settings - adjusted, as necessary, to obtain satisfactory exposure.

F30.4 Film. The X-ray film shall be single emulsion and of a grade defined as very fine grain.

F30.4.1 Sensitivity. X-ray film and equipment shall be capable of detecting metallic particles with a major dimension of 0.004 inch (0.10 millimeters) or greater.

F30.4.2 Exposure. Exposure factors such as KVP, current, and time shall be compatible with the sensitivity requirements of F30.4.1.

F30.4.3 Film density. The X-ray equipment and processing techniques shall be capable of producing H and D film density of 1.5 to 3.0 in accordance with the American Standard Printing density type P-2.

F30.4.4 Film dimensions. Radiographic film shall not exceed 14 inches (35.56 centimeters) in width and 17 inches (43.18 centimeters) in length.

F30.4.5 Processing. The exposed X-ray film shall be processed in such manner that the film shall be free of processing defects, i.e., fingerprints, chemical spots, blemishes, etc.

F30.4.6 Film identification. Each radiographic film shall be identified with the following information:

- a. Part manufacturer's name.
- b. Part number (as marked on part).
- c. Part cross reference.

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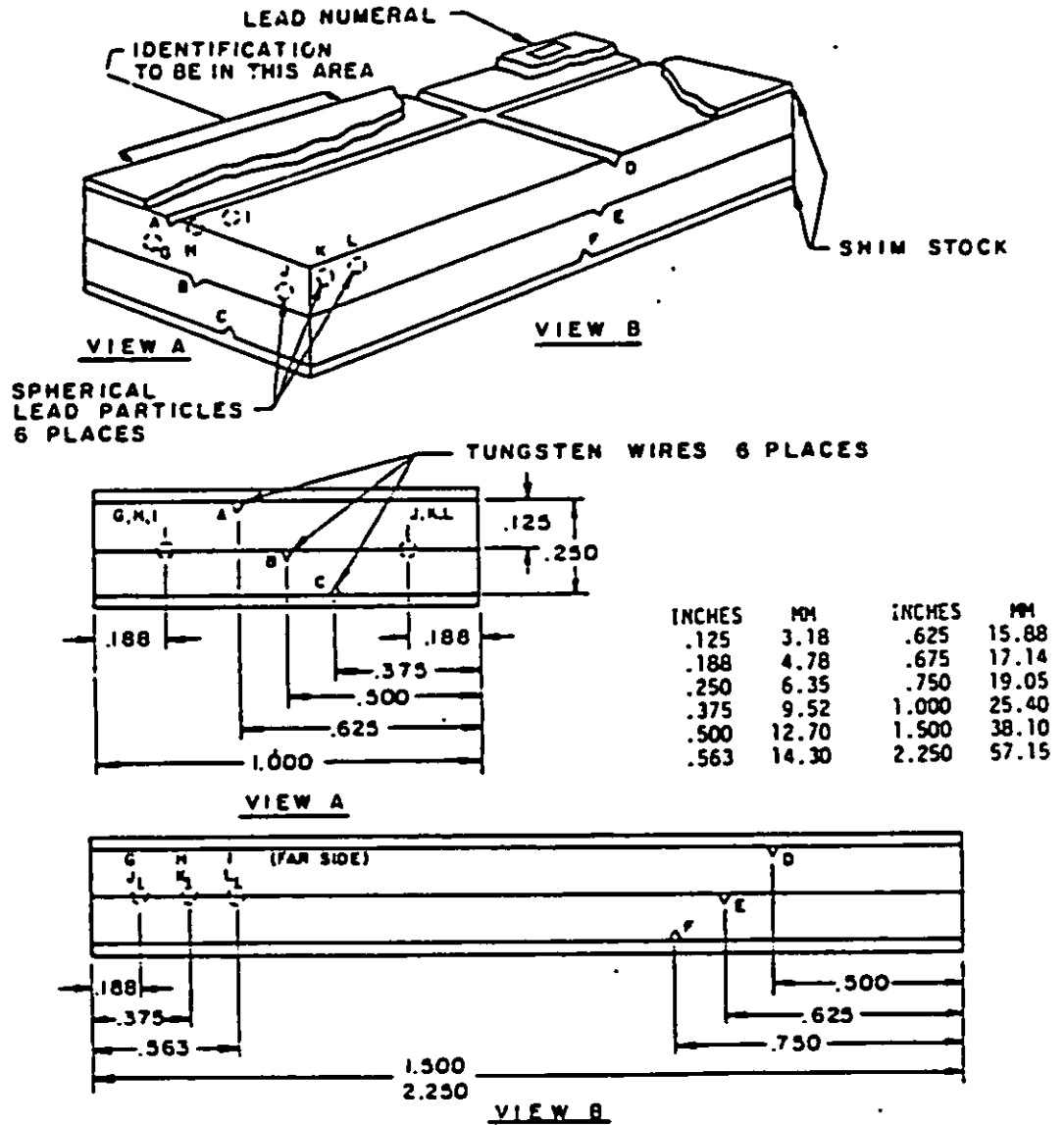


FIGURE F1. Penetrameter.

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Tungsten wire diameters						Lead particle diameters						Steel shim stock
A	B	C	D	E	F	G	H	I	J	K	L	
.002 (.05)	.001 (.03)	.0005 (.013)	.0005 (.013)	.001 (.03)	.002 (.05)	.015 (.38)	.010 (.25)	.008 (.20)	.006 (.15)	.004 (.10)	.002 (.05)	None
												.002 (.05)
												.005 (.13)
↓	↓	↓	↓	↓	↓							.007 (.18)
.003 (.08)	.002 (.05)	.001 (.03)	.001 (.03)	.002 (.05)	.003 (.08)							.010 (.25)
.003 (.08)	.002 (.05)	.001 (.03)	.001 (.03)	.002 (.05)	.003 (.08)							.015 (.38)
.005 (.13)	.003 (.08)	.002 (.05)	.002 (.05)	.003 (.08)	.005 (.13)							.025 (.64)
.005 (.13)	.003 (.08)	.002 (.05)	.002 (.05)	.003 (.08)	.005 (.13)	↓	↓	↓	↓	↓	↓	.035 (.89)

NOTES:

1. Dimensions are in inches.
2. Metric equivalents are given for general information only and are based upon 1.00 inch = 25.4 mm.
3. Wires to be tungsten, shim stock to be carbon steel, particles to be lead. Center section to be .125 (3.18 mm) layers of clear acrylic plastic, bonded with clear plastic cement of low X-ray density. Fasteners may be used within .250 inch (6.35 mm) or less from each corner, but shall not interfere with end use of the penetrometer. Bottom surface shall be flush.
4. All dimensions, shown are $\pm .005$ inch (.13 mm), except wires, and shim stock, which shall be within standard mill tolerances and lead particles which shall be $\pm .0002$ inch (.005 mm). Groove details are not critical except that wire must be embedded flush or below surface of plastic and centered at location shown. Particle-hole sizes are not critical, but should not exceed .031 (.79 mm) in diameter and depth, and must be centered as shown ($\pm .005$ inch) (.13 mm).
5. Additional layers of shim stock may be used as necessary.
6. Identification marking shall be permanent and legible. Location and size of characters is not critical but shall not interfere with or obscure the radiographic image details.

FIGURE F1. Penetrometer - Continued.

- d. Date or lot code (as marked on part).
- e. View number.
- f. X-ray laboratory name.
- g. Penetrameter image.
- h. Penetrameter number (see figure F1).

F30.5 Penetrameters. Penetrameters shall be employed in all radiographic testing and shall be as specified in figure F1. The penetrameter image shall be used to determine radiographic quality and shall meet the following requirements:

- a. Penetrameter wires shall be visible on each radiograph.
- b. Penetrameters shall be selected to give a film density within +10 percent of the density of the area of immediate interest.
- c. Penetrameters shall be placed in diagonal corners on the source side of the film. The plane of the penetrameters shall be normal to the radiation beam. When 35-mm film strip is used, the penetrameter shall be placed in a position normally occupied by a part, and a penetrameter image shall be made (exposed) for every 50 parts or 17 inches (43.18 centimeters) of film, whichever is more convenient.
- d. Distortion of any penetrameter shall not exceed 10 percent.
- e. The spacing between wires of a penetrameter shall not be distorted by more than 10 percent. The percentage of distortion as used in this standard is defined as follows:

$$\text{Percentage distortion} = \frac{S_0 - S_1}{S_0} \times 100 \text{ where}$$

S_0 = actual wire spacing, and

S_1 = wire spacing as it appears on the X-ray film.

F30.6 Fixtures. Suitable fixtures shall be used for mounting the electronic parts during the X-ray operation.

F30.6.1 Mounting of parts. The capacitors may be mounted in any type of fixture, provided that any metallic portion of the fixture is not between the body of the capacitor and the film.

F30.6.2 Identification of capacitors. Each capacitor shall be traceable from its position on the fixture to its corresponding image on the film until completion of film inspection and identification of any with rejectable defects.

F30.7 Inspection and examination of radiographs. Inspection of radiographs shall be conducted by the device manufacturer. Each radiograph shall be examined, utilizing the equipment specified herein. The radiographs shall be inspected to determine that each capacitor conforms to the requirements of this document.

F30.7.1 Viewing equipment. The radiograph shall be examined on a suitable illuminator with variable intensity, or on a viewer suitable for radiographic inspection of projection type viewing equipment.

F30.7.2 Magnification. A magnification of 10 power minimum shall be used for radiograph examination.

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F40. MARKING

F40.1 Marking of parts. Capacitors that have been X-rayed and have been found acceptable shall be identified with a blue dot on the external case. The blue dot shall be approximately 0.0625 inch (1.5 mm) in diameter and shall be of fungus-resistant paint.

F50. REPORTS AND RECORDS

F50.1 Report of inspection. Unless otherwise specified by the contract, the testing activity shall furnish inspection reports signed by an authorized representative of the testing activity. The reports shall give the results of the radiographic inspection and shall list the part number, the number of parts inspected, the number of parts rejected, and the date of the test.

F50.2 Records of inspection. A complete record of details of inspection shall be kept by the manufacturer or testing laboratory. The record shall list the voltage potentials and currents used in the radiographic process, the time of exposure, the distance of the source of radiation from the surface of the part, the distance of the film from the same surface, the approximate angle between the central beam of radiation and the film, the screens and filters used, the size of the focal spot, the time of development of the film and the part number and lot or date code of the capacitors.

F50.3 Records of radiographs. Each radiograph shall carry a radiograph inspection serial number or code letters to identify the radiograph with the parts examined shown in the radiograph. One complete set of radiographs shall be kept by the manufacturer for a period of 3 years minimum.

F60. PERSONNEL

F60.1 Radiographer. Personnel engaged in radiographic processing shall be familiar with the requirements of this standard and with all applicable documentation controlling radiographic quality of parts and materials being inspected. They shall be certified by their employer to be capable of producing radiographs which meet the requirements of all applicable documentation.

F60.2 Radiographic interpreters. Personnel engaged in the interpretation of radiographs shall be familiar with the requirements of this standard and with all applicable documentation controlling radiographic quality of parts and materials being inspected. They shall be certified by their employer to be capable of evaluating radiographs to determine conformance of parts and materials to the requirements of all applicable documentation.

F60.3 Vision. The minimum vision requirements for visual acuity of personnel inspecting film shall be as follows:

- a. Distant vision shall equal 20/30 in at least one eye, either corrected or uncorrected.
- b. Near vision shall be such that the individual can read Jaeger type No. 2 at a distance of 16 inches (40.64 centimeters) either corrected or uncorrected.

F60.4 Vision tests. Vision tests shall be performed by an oculist, optometrist, or by other professionally recognized personnel. One year from the effective due date of original certification, and each year thereafter, certified personnel shall be required to pass the vision tests specified herein.

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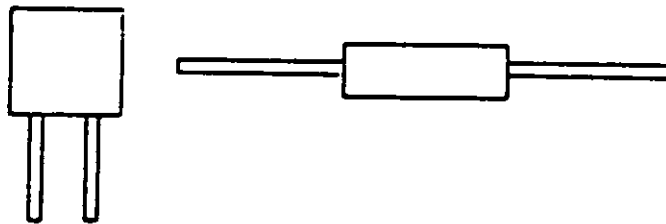


FIGURE F2. Viewing planes for radiographic inspection.

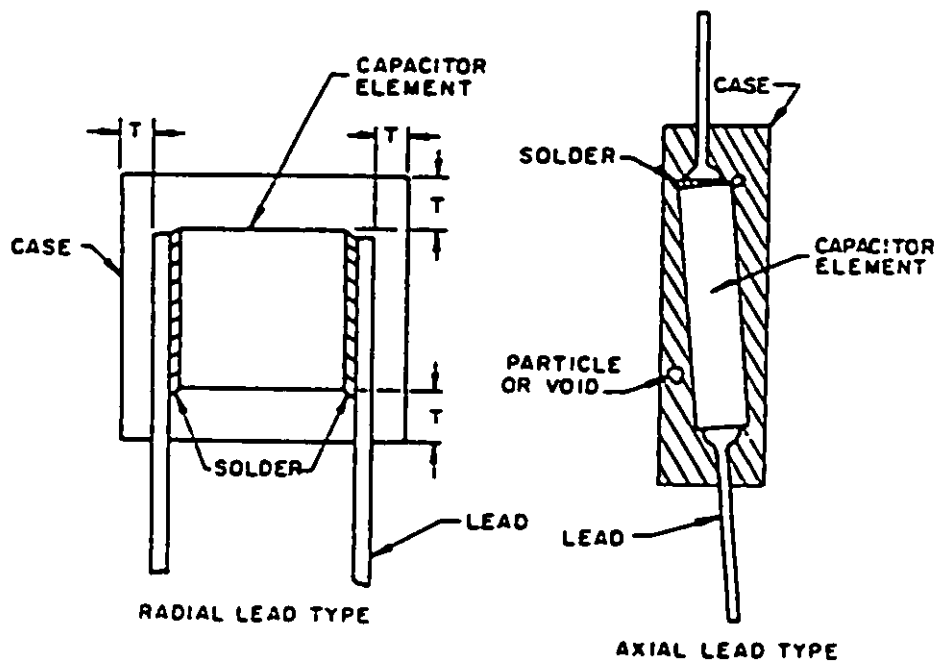


FIGURE F3. Acceptance criteria for radiographic inspection.

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APPENDIX G

PRE-ENCAPSULATION VISUAL INSPECTION CRITERIAL FOR LEADED CAPACITORS

G10 SCOPE

G10.1 Scope. This appendix specifies the visual inspection criteria for leaded capacitors. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

G20. Applicable documents. This section is not applicable to this appendix.

G30 PROCEDURES FOR INSPECTION AND REJECTION

G30.1 Method of inspection. Each device shall be examined under 7 power minimum magnification to determine compliance with the requirements specified herein.

G30.2 Rejection criterial for both axial and radial leaded devices. Devices that deviate from the material, design, or construction requirements specified, or that fail to meet the following requirements or those specified in G40 shall be unacceptable.

G30.2.1 Chip examination.

- a. Cracks in the ceramic (thermal shock cracks).
- b. Open delaminations in chips which expose internal electrode material.
- c. "Cold" solder joints (frosted or granular in appearance).
- d. Solder bridging or potential bridging between opposing terminations.
- e. Excess solder.
- f. No solder balls on leads.

G40 SPECIFIC LEAD REJECTION CRITERIA

G40.1 Axial leaded devices - Criteria/Assessment

- Unit A. Ideal lead to element union. Acceptable.
- Unit B. Solder build-up (fillet) on one side only. Acceptable.
- Unit C. No solder build-up (fillet), but good element to chip interface. Acceptable.
- Unit D. Edge of lead wire does not overhang the edge of the element, and full solder coverage is evidenced. Acceptable.
- Unit E. Gap in solder joint under the nail head which reduces lead to element interface to less than 90 percent coverage. Rejectable.
- Unit F. Gap in solder joint under the nail head which reduces lead to element interface to less than 90 percent coverage. Rejectable.
- Unit G. Gaps or voids in solder joint under the nail head which reduces lead to element interface to less than 90 percent coverage. Rejectable.
- Unit H. Gap in solder joint under the nail head which reduces lead to element interface to less than 90 percent coverage. Rejectable.
- Unit I. Diameter of lead wire overhangs side of element. Rejectable. (Note, nail head may overhang.)
- Unit J. Edge of lead wire does not overhang edge of element, but, gap in solder joint under the nail head reduces lead to element interface to less than 90 percent coverage. Rejectable.
- Unit K. Center line of nail head tilted greater than 30° beyond center line of chip. Rejectable.

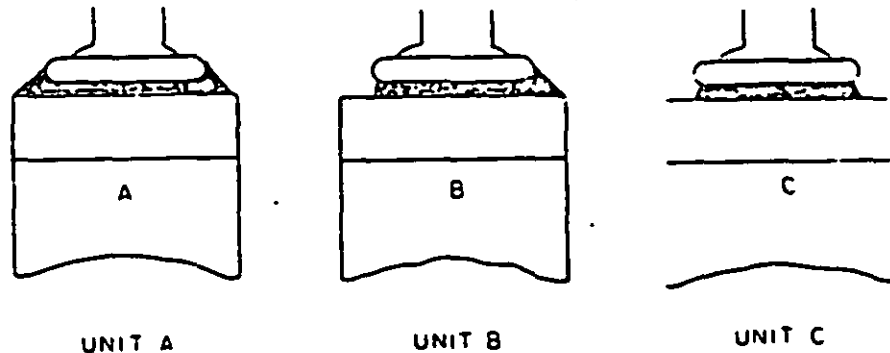


FIGURE G1. Acceptable units.

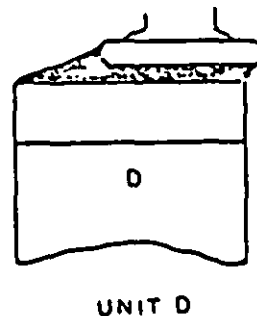


FIGURE G2. Acceptable only by QC department.

G40.2 Radial leaded devices (molded) - Criteria/Assessment

- Unit M. Ideal condition for a radial leaded device prior to encapsulation. Acceptable.
- Unit N. Element thickness is greater than or equal to the average lead wire flat dimension. The element must be positioned such that the lead wire flat does not extend more than 1/3 beyond the thickness of the element. This example is rejectable.
- Unit O. Element thickness is less than the average lead wire flat dimension. The element must be positioned such that the lead to element interface is a minimum of 80 percent of the available contact area. This example is rejectable.
- Unit P. Angle between chip centerline and lead centerline shall not exceed 30°.
- Unit Q. Ideal chip alignment (top view). Acceptable.
- Unit R. If the element thickness is greater than or equal to the average lead wire flat dimension, the element must be positioned such that the lead wire flat does not extend more than 1/3 beyond the thickness of the element.

If the element thickness is less than the average lead wire flat dimension, the element must be positioned such that the lead to element interface is a minimum of 90 percent of the available contact area. This example is rejectable (top view).

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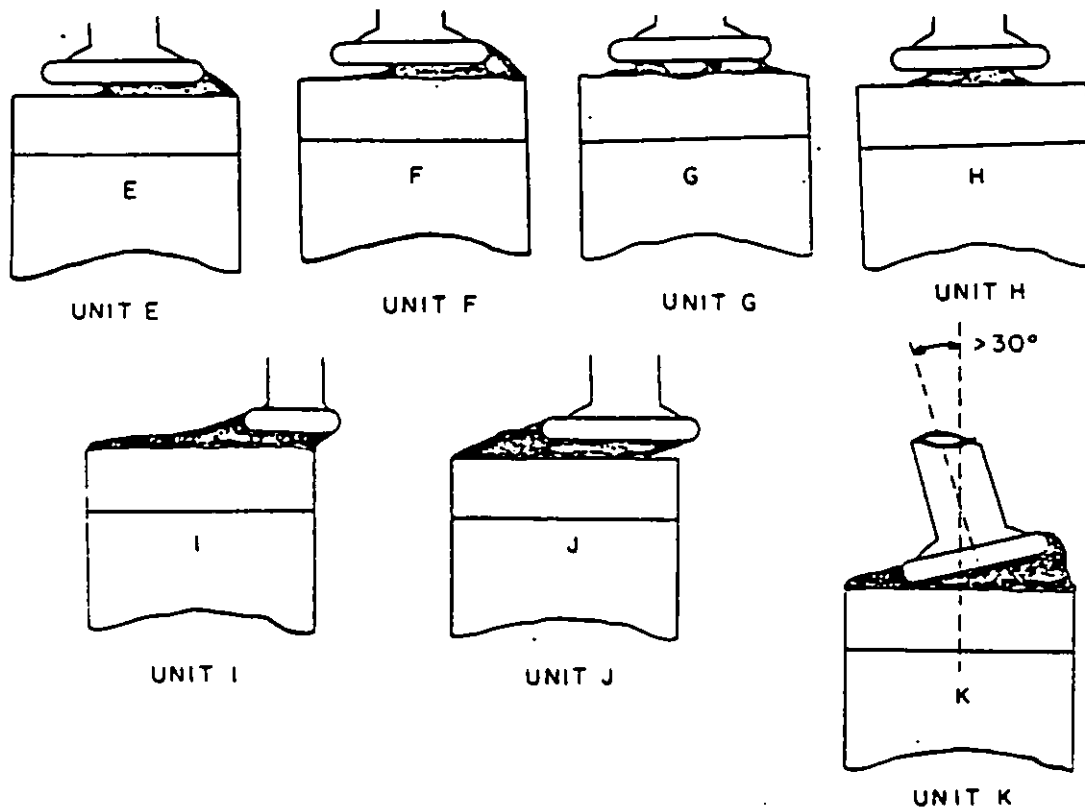


FIGURE G3. Rejectable devices.

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APPENDIX G

Unit 5. This example shows various rejectable characteristics which may be observed on the radial leaded device. Description of the numbered defects are as follows:

- (1) Lead to element interface less than 80 percent are not acceptable.
- (2) Cut, dent, or smash in the lead wire exceeding .050" in length or .005" in depth.
- (3) Element is not properly seated in the "saddle." Gaps in excess of .015" are rejectable.
- (4) Chip outs in the ceramic surface which expose electrodes are not acceptable.

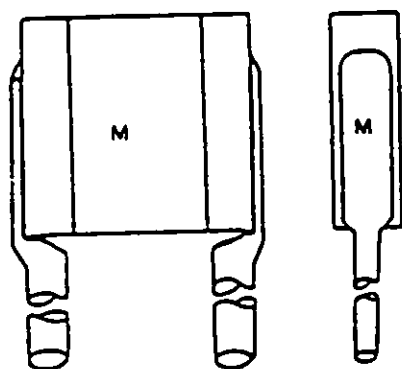


FIGURE G4. Ideal condition (acceptable unit).

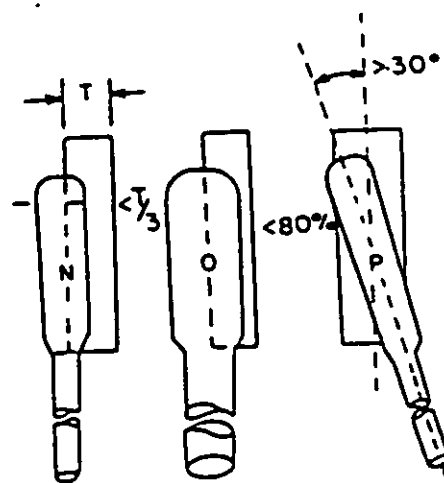
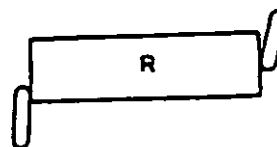


FIGURE G5. Rejectable units.



ACCEPTABLE



REJECTABLE

FIGURE G6. Chip alignment.

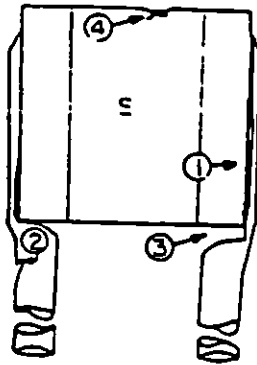


FIGURE G7. Rejectable characteristics.

G40.3 Radial leaded devices (epoxy coated) - Criteria/Assessment

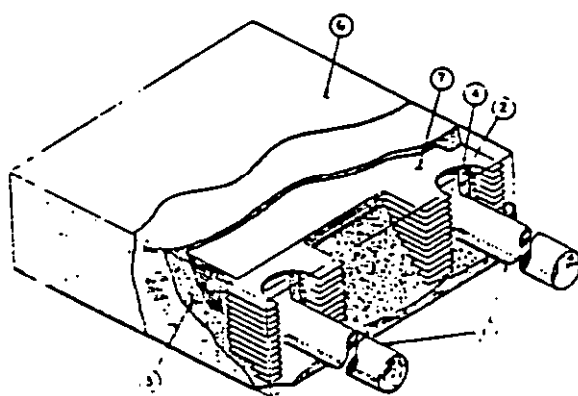
G40.3.1 Leads shall be 100 percent covered with solder.

G40.3.2 There shall be no voids under the lead head.

G40.3.3 The solder fillet shall not extend more than one lead diameter in distance down the lead from the bottom edge of the chip.

G40.3.4 There shall be no crack or separation between the lead and chip.

G40.3.5 Leads shall not be off center by more than .015 inch.



- ① Lead Wire
- ② Solder
- ③ Dielectric
- ④ End Silver Frit
- ⑤ End Solder
- ⑥ Case
- ⑦ Electrode

FIGURE G8. Typical (non molded) device with epoxy coat.

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